FLORIDA GEOLOGICAL SURVEY

SEVENTH ANNUAL REPORT

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FLORIDA STATE GEOLOGICAL SURVEY

E. H. SELLARDS, Ph. D., State Geologist

SEVENTH ANNUAL REPORT

Published For
THE STATE GEOLOGICAL SURVEY
Tallahassee, 1915

LETTER OF TRANSMITTAL.

To His Excellency, Hon. Park Trammell, Governor of Florida.

SIR:—In accordance with the Survey law I submit herewith my Seventh Annual Report as State Geologist of Florida. This report contains the statement of expenditures by the Survey for the year ending June 30, 1914, together with those investigations by the Survey that have progressed far enough to be available for publication.

Permit me to express in this connection my appreciation of the interest you have shown in the work of the State Geological Survey.

Very respectfully,

E. H. SELLARDS,
State Geologist.

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ADMINISTRATIVE REPORT.

E. H. SELLARDS, STATE GEOLOGIST.

PUBLICATIONS ISSUED BY THE STATE GEOLOGICAL SURVEY.

The following is a list of the publications issued by the State Geological Survey since its organization:

ANNUAL REPORTS.

First Annual Report, 1908, 114 pp., 6 pls.

This report contains: (1) a sketch of the geology of Florida; (2) a chapter on mineral industries, including phosphate, kaolin or ball clay, brick-making clays, fuller's earth, peat, lime and cement and road-making materials; (3) a bibliography of publications on Florida geology, with a review of the more important papers published previous to the organization of the present Geological Survey.

Second Annual Report, 1909, 299 pp., 19 pls., 5 text figures, and one map.

This report contains: (1) a preliminary report on the geology of Florida, with special reference to stratigraphy, including a topographic and geologic map of Florida, prepared in co-operation with the United States Geological Survey; (2) mineral industries; (3) the fuller's earth deposits of Gadsden County, with notes on similar deposits found elsewhere in the State.

Third Annual Report, 1910, 397 pp., 28 pls., 30 text figures.

This report contains: (1) a preliminary paper on the Florida phosphate deposits; (2) some Florida lakes and lake basins; (3) the artesian water supply of eastern Florida; (4) a preliminary report on the Florida peat deposits.

Fourth Annual Report, 1912, 175 pp., 16 pls., 15 text figures, one map.

This report contains: (1) the soils and other surface residual materials of Florida, their origin, character and the formations from which derived; (2) the water supply of west-central and west Florida; (3) the production of phosphate rock in Florida during 1910 and 1911.

Fifth Annual Report, 1913, 306 pp., 14 pls., 17 text figures, two maps.

This report contains: (1) Origin of the hard rock phosphates of Florida; (2) list of elevations in Florida; (3) artesian water supply of eastern and southern Florida; (4) production of phosphate in Florida during 1912; (5) statistics on public roads in Florida.

Sixth Annual Report, 1914, 451 pp., 90 figures, one map.

This report contains: (1) mineral industries and resources of Florida; (2) some Florida lakes and lake basins; (3) the relation between the Dunnellon formation and the Alachua clays of Florida; (4) geography and vegetation of northern Florida.

Seventh Annual Report (this volume).

BULLETINS.

Bulletin No. 1. The Underground Water Supply of Central Florida, 1908, 103 pp., 6 pls., 6 text figures.

This report contains: (1) Underground water; general discussion; (2) the underground water of central Florida, deep and shallow wells, spring and artesian prospects; (3) effects of underground solution, cavities, sinkholes, disappearing streams and solution basins; (4) drainage of lakes, ponds and swamp lands and disposal of sewage by bored wells; (5) water analyses and tables giving general water resources, public water supplies, spring and well records.

Bulletin No. 2. Roads and Road Materials of Florida, 1911, 31 pp., 4 pls.

This bulletin contains: (1) An account of the road building materials of Florida; (2) a statistical table showing the amount of improved roads built by the counties of the State to the close of 1910.

PRESS BULLETINS.

In addition to the regular reports of the Survey as listed above, press Bulletins have been issued as follows:

No. 1. The Extinct Land Animals of Florida, February 6, 1913.

No. 2. Production of Phosphate Rock in Florida during 1912, March 12, 1913.

No. 3. Summary of Papers Presented by the State Geologist at the Atlanta Meeting of the American Association for the Advancement of Science, December 31, 1913.

No. 4. The Utility of Well Records, January 15, 1914.

No. 5. Production of Phosphate Rock in Florida during 1913, May 20, 1914.

No. 6. The Value to Science of the Fossil Animal Remains Found Imbedded in the Earth, January, 1915.

No. 7. Report on Clay Tests for Paving Brick, April, 1915.

Press Bulletin No. 6 is included herewith. Press Bulletin No. 7 is included under Mineral Industries. The other press bulletins, with the exception of No. 3, are included in the preceding reports of the Survey.

DISTRIBUTION OF REPORTS.

The reports issued by the State Geological Survey are distributed upon request, and may be obtained without cost by addressing the State Geologist, Tallahassee, Florida. Requests by those living outside of the State of Florida should be accompanied by postage, or if desired the reports will be sent express collect.

THE VALUE TO SCIENCE OF THE FOSSIL ANIMAL REMAINS FOUND IMBEDDED IN THE EARTH.*

The value to science of the fossil animal remains found imbedded in the earth is sometimes not fully appreciated. To the geologist, fossils are not curios or objects of temporary interest, but are working tools, since it is chiefly by them that the age of the deposits in which they occur is determined. Each formation and geologic time division is characterized more or less definitely by the animals and plants that were then living. In passing from one formation to another a change is observed in the animal and plant life, which among other things determines the limits of the formation. In some of the European countries the value of fossils to science is much more fully recognized than in America, and it is required by law that fossils when found be preserved. It is very much to be hoped that in this country the true value of fossils may be more fully appreciated, and that all that are found may be cared for. This is especially to be desired in Florida where the rapid developments that are now in progress result in extensive excavations, not only in connection with mining operations, but also in connection with the drainage of lands, harbor and river dredging, and other general improvements. These operations are bringing to light many animal remains that have been imbedded in the earth for ages, and it certainly would be exceedingly unfortunate if these were allowed to be destroyed.

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*First published as Press Bulletin No. 6. January, 1915.

Some progress has been made in the study of the extinct life of Florida and already we have record of the presence in the State during earlier times of many animals which are now either entirely extinct or are found only in remote parts of the earth. Among the land animals that formerly lived in Florida the following may be mentioned as of special interest. The list here given, however, is by no means complete.

THE ELEPHANTS.

In former times the elephants, now found native only in Africa and Asia, were present in North America, and extended their range into Florida, their remains having been found at many localities throughout the State. The parts of the skeleton most commonly found are isolated bones, grinding teeth and tusks, the large size of which invariably attracts attention. The elephant found in Florida is not the mammoth of the northern states, but is the Columbian elephant, *Elephas columbi.* Some of the teeth, however, closely resemble those of the Imperial elephant which was formerly abundant in the western part of the United States and it is possible that both species were present in Florida. In addition to the true elephants, there were present in Florida, as shown by their fossil remains, at least two species of the mastodons or primitive elephants. One of these, the American mastodon, known as *Mammut americanum,* was contemporaneous with the elephant, or possibly endured on this continent longer than did the elephant. The other mastodons of Florida, of which there may be more than one species, existed at a time previous to the appearance either of the true elephants or of the American mastodon, and are found only in deposits older than those in which is imbedded the remains of the elephant.

THE HORSES.

Florida was evidently the home, through long geologic periods, of various species of the horse family. In the comparatively late formations is found remains of the true horse, *Equus,* which, however, differs from the domestic horse, which was re-introduced from Europe after the horses native to America had become extinct. In the somewhat older formations are found earlier, smaller and more primitive horses which were evidently the associates of the early mastodons, being imbedded in the same deposits. These early members of the horse family are placed under the genus *Hipparion.*

THE RHINOCEROSES.

It is of much interest to find that the rhinoceroses at one time made up an important element in the land fauna of Florida, being found in the Pliocene deposits of central Florida in association with those of the early horse and mastodon, the remains of all of which have been brought to light in connection with phosphate mining. Two species of rhinoceroses are recognized, one of which included stocky and heavy built animals, while the other kind was more nearly of the proportions of the modern rhinoceroses of Africa and Asia. Neither, however, were identical with any of the species now living.

CAMELS, LLAMAS AND TAPIRS.

The camels, another group of animals now found only in Asia and Africa, and their relatives the llamas, now confined to South America, were formerly present in the United States and extended their range into Florida. The tapirs, likewise, were formerly native to Florida. The camel remains are found in association with those of the rhinoceros and pertain to species not now in existence. The tapir and llama remains are found for the most part in comparatively recent geologic deposits and represent species closely related to, if not identical with those now living.

SLOTHS AND ARMADILLOS.

Among other animals formerly present in Florida should be mentioned members of the sloth tribe, the modern representatives of which are now found only in South America. With the sloths is associated an armadillo-like animal, much larger, however, than the modern armadillos. The sloths found fossil in Florida were also larger than those now living. The Glyptodons, now entirely extinct, is another group closely related to the armadillos, which are also represented by fossil remains in Florida.

While some progress has been made, it is evident that much yet remains to be learned of the animals of the past in Florida. It is sometimes supposed that only the larger animals are of interest. This is not true since for geologic purposes the small animals are equally as important as the large. Fragmentary remains are also frequently of value, since the presence of a single tooth or bone may prove the presence of a species in a formation. Vertebrate and invertebrate, land and marine animals are all of value in the study of the geology of the State.

Will you not lend your aid to the work of the State Geological Survey by preserving the fossils that are found in your neighborhood or in connection with your own work and submitting them to the State Geologist?

Valuable assistance has already been rendered the Survey in this way by the various mining companies and by individuals, all of which help is very much appreciated.

EXPENDITURES OF THE GEOLOGICAL SURVEY FOR THE YEAR ENDING JUNE 30, 1914.

The total appropriation for the State Geological Survey is $7,500 per annum. No part of this fund is handled direct by the State Geologist, as all survey accounts are paid upon warrants drawn upon the Treasurer by the Comptroller as per itemized statements approved by the Governor. The original of all bills and the itemized statements of all expense accounts are on file in the office of the Comptroller. Duplicate copies of the same are on file in the office of the State Geologist. The warrants when paid are on file in the office of the State Treasurer.

List of warrants issued during the year ending June 30, 1914:

JULY, 1913.

Alex Walton, janitor service	$ 10.00
Dan Allen, drayage	4.50
D. R. Cox Furniture Company, supplies	8.25

AUGUST, 1913.

E. H. Sellards, State Geologist, expenses, August, 1913	49.04
Alex McDougall, postage	25.00
E. H. J. Lorenz, maps	80.00
Alex Walton, janitor services	10.00

SEPTEMBER, 1913.

E. H. Sellards, State Geologist, salary for quarter ending September 30, 1913	625.00
E. H. Sellards, State Geologist, expenses, September, 1913	38.40
Herman Gunter, Assistant, salary for quarter ending September 30, 1913	375.00
Laura Smith, stenographic services	75.00
F. C. Gilmore, carpenter work	2.00
Alex Walton, janitor services	10.00

OCTOBER, 1913.

A. Hoen & Company, maps of Florida	237.00
Alex McDougall, postage	25.00
Dan Allen, freight and drayage	4.94
Alex Walton, janitor services	10.00
Herman Gunter, assistant, expenses, October, 1913	22.40
E. H. Sellards, State Geologist, expenses, October, 1913	51.13

NOVEMBER, 1913.

E. H. Sellards, State Geologist, expenses, November, 1913	101.58
Herman Gunter, assistant, expenses, November, 1913	64.85
Southern Express Company	1.60

Dan Allen, freight and drayage	2.32
Alex Walton, janitor services	10.00
Alex McDougall, postage	125.00
The Lettershop	2.25

DECEMBER, 1913.

E. H. Sellards, State Geologist, salary for quarter ending December 31, 1913	625.00
Herman Gunter, assistant, salary for quarter ending December 31, 1913	375.00
Laura Smith, stenographic services	75.00
Alex Walton, janitor services	10.00
Collins Printing Company, printing	2.50
Southern Express Company	5.36
Alex McDougall, postage	25.00

JANUARY, 1914.

E. H. Sellards, State Geologist, expenses	14.95
Herman Gunter, Assistant, expenses, January, 1914	28.75
Alex McDougall, postage	2.75
Southern Express Company	2.71
A. Hoen & Co.	210.00
H. & W. B. Drew Company	15.47
The Letter Shop	5.25
Engineering & Mining Journal, subscription	5.00
Economic Geology Publishing Co., subscription	3.00
American Journal of Science, subscription	6.00
T. J. Appleyard, State Printer	71.00
Dan Allen, freight and drayage	7.54

FEBRUARY, 1914.

E. H. Sellards, State Geologist, expenses	68.55
Herman Gunter, Assistant, expenses	41.05
Alex McDougall, postage	50.00
Ware Bros., Subscription American Fertilizer	5.00
Alex Walton, janitor services	20.00

MARCH, 1914.

E. H. Sellards, State Geologist, salary for quarter ending March 31, 1914	625.00
Herman Gunter, Assistant, salary for quarter ending March 31, 1914	375.00
Laura Smith, stenographic services	75.00
Ed Lomas, janitor services	10.00
Alex McDougall, postage	25.00
J. K. Small, publications	6.50
G. E. Stechert & Co., publications	7.50
D. R. Cox Furniture Company, supplies	18.40
American Peat Society, publications	3.00
Southern Express Company	3.25
MacMillan Company, publications	12.75
R. M. Harper, salary, March, 1914, $110.00; expenses, $33.60	143.60

APRIL, 1914.

R. M. Harper, salary, April, 1914	125.00
Southern Express Company	2.86
McGraw-Hill Book Co., publications	4.00
Dan Allen, freight and drayage	4.27
Standard Supply Company, supplies	9.97
University of Chicago Press, publications	2.45
W. B. Scott, publications	19.43
Dodd, Mead & Co., publications	1.83
D. R. Cox Furniture Company, supplies	78.40

MAY, 1914.

E. H. Sellards, State Geologist, expenses, March, April and May, 1914	128.93
Herman Gunter, Assistant, expenses, May, 1914	36.13
R. M. Harper, salary, May, 1914, $125.00; expenses, $16.62	141.62
T. J. Appleyard, State Printer	15.00
University of Chicago Press, subscription	3.60
Dan Allen, freight and drayage	10.31
Andrus & Church, supplies	22.30
Southern Express Company	3.20
David S. Woodrow, agt. Phosphate Industry	6.00
Alex McDougall, postage	25.00
F. C. Gilmore, supplies	4.75

JUNE, 1914.

E. H. Sellards, State Geologist, salary for quarter ending June 30, 1914	625.00
Herman Gunter, Assistant, salary for quarter ending June 30, 1914	375.00
R. M. Harper, salary, June, 1914	125.00
Laura Smith, stenographic services	75.00
Alex McDougall, postage	98.68
Ed Lomas, janitor services	30.00
Max Schmidt, bookdealer	2.41
H. & W. B. Drew Co., supplies	2.95
Dan Allen, freight and drayage	3.31
D. R. Cox Furniture Company, supplies	129.50
E. O. Painter Printing Co., printing	2,247.75
Total	$9,309.79

Appropriation for the year	$7,500.00	
Available from the preceding year	2,418.47	
		$9,918.47
Total expenditures for the year ending June 30, 1914		9,309.79
Balance		$ 608.68

STATISTICS ON
MINERAL INDUSTRIES OF FLORIDA
CALENDAR YEAR, 1914.

BY E. H. SELLARDS.

STATISTICS COLLECTED IN CO-OPERATION WITH THE UNITED STATES GEOLOGICAL SURVEY.

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STATISTICS ON MINERAL INDUSTRIES OF FLORIDA FOR THE CALENDAR YEAR, 1914.

E. H. SELLARDS.

CLAY AND CLAY PRODUCTS.

BALL CLAY OR PLASTIC KAOLIN.

Two plants, The Edgar Plastic Kaolin Company and The Lake County Clay Company, were engaged in mining ball clay in Florida during 1914. In addition The Richmond China Clay Company had a plant under construction with the expectation of operating during 1915. The value of the ball clay produced, although not separately given, is included in the total mineral products of the State.

BRICK AND TILE.

The total number of common brick manufactured in Florida during 1914 was 41,901,000, valued at $230,377. The quantity of tile, hollow block brick and other clay products is not separately given, but is included in making up the total mineral products of the State.

The following firms in Florida have reported production of brick or tile during 1914:

Barrineau Brothers, Quintette.
Campville Brick Company, Campville.
Clay County Steam Brick Company, Green Cove Springs.
Florida Brick Company, Brooksville.
Florida Industrial School for Boys, Marianna.
Gamble and Stockton Company, 108 West Bay St., Jacksonville.
Hall and McCormac, Chipley.
Keystone Brick Company, Whitney.
McMillan Brick Company, Molino.
O. O. Mickler Brick Company, Callahan.
Ocklocknee Brick Company, Ocklocknee.
Platt Brothers, South Jacksonville.
Tallahassee Pressed Brick Company, Havana.

REPORT ON CLAY TESTS FOR PAVING BRICK.*

As a country develops, the demand for information regarding the clay products as well as the other natural resources, becomes the more insistent. This is particularly true in Florida where the extensive use of brick for road paving has created a large demand for a product that is not now being made in the State. At the present time all the paving brick used in Florida is imported, and the question is constantly being asked whether or not there exists in the State a clay suitable for the manufacture of vitrified brick. A source of domestic supply, if such can be found, will not only effect a saving in freight rates, but in addition will bring an important new industry into the State. In view of these facts the State Geological Survey has undertaken to find, if possible, a clay in the State suitable for the manufacture of paving brick. Even should no paving brick clay be found, the general information regarding clay deposits of the State that will be obtained in connection with these investigations will abundantly justify the undertaking.

In this work the State Survey has been particularly fortunate in having secured during the past year the assistance of the United States Bureau of Standards. This Federal Bureau maintains at Pittsburgh, Pennsylvania, an excellently equipped clay testing laboratory in which, through the generous co-operation of the Director of the Bureau, the actual burning tests of the Florida clays have been made. For this purpose twenty-five samples were collected by the State Geological Survey and submitted to the Bureau during the summer of 1914. Twenty-one counties in Florida are represented in these tests. Each sample as shipped consisted of approximately 250 pounds of clay and was representative, as nearly as could be judged, of the clay of the locality from which it was taken. The burning tests have been made by experienced ceramists under favorable conditions and the results may be accepted with confidence.

PREPARATION OF SAMPLES.

After being received at the Pittsburgh laboratory the samples were prepared by the ceramists who were making the tests as follows:

"*Preparation of the Sample.*—Each sample as received was ground in a Stevenson pan and screened through a 10-mesh sieve.

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*First published as Press Bulletin No. 7, April, 1915.

A portion of the samples was tempered with water and wedged on a marble slab until it acquired stiff mud consistency.

"*Preparation of Test Pieces.*—Twenty-four briquettes were molded from each clay by pressing in the stiff mud condition on a hand repress machine, the test pieces being numbered consecutively from 1 to 24. Test pieces Nos. 1, 2, 3, and 4 from each batch were weighed in the moist state and after drying, and the water of plasticity calculated in terms of the dry weight of the clay. Linear measurements were also made on test pieces Nos. 1, 2, 3, and 4 and the linear shrinkage in terms of the wet length of the briquettes determined.

"*Drying Treatment.*—Each series of briquettes were allowed to dry at room temperatures until they had acquired leather hard consistency, the final drying being in an electrically heated drying oven at 75° and 110° C.

"*Burning.*—The test pieces were burned in a down-draft test kiln fired with natural gas. The duration of burning was about 36 hours, the kiln temperature being increased at the rate of 25° C. per hour above 850° C. The kiln temperatures were measured by platinum-platinum rhodium thermocouples and recording millivolt meters. Four burns were made on the 24 samples. The twenty-four test pieces molded from each sample were arranged in the kiln so that two could be drawn at regular temperature intervals. Thus two briquettes from sample No. 1 were drawn at 850° C., 950° C., 980° C., and so on to the final burning temperature. The briquettes were dropped into hot sand as they were drawn from the kiln.

"*Porosity Determinations.*—The porosities of the briquettes burned to the different temperatures were determined by the use of the formula, $\frac{W - D}{W - S} \times 100 = \%$ porosity, in which W = the weight of the briquette saturated with water, D = the dry weight of the briquette, and S = the suspended weight of the briquette. Before determining the wet weights the pieces were boiled two hours in water in vacuo."

The examination of the clay samples thus prepared included the determination of: The molding behavior; the water of plasticity in percentage of dry weight; the drying behavior; the linear drying shrinkage in terms of wet length; the linear burning shrinkage in terms of dry length; the color after burning; and the percentage of porosity at temperatures ranging from 850 to 1320 degrees C. (1562° to 2408° F).

RESULTS.

Although, as will be seen in the report which follows, the tests thus far made are negative, so far as paving brick are concerned, yet the results obtained are such as to justify the continuation of the investigation.

With regard to the tests as a whole it is of interest to find that a fair number of the Florida clays of which samples were submitted show satisfactory molding, drying and other working properties, and may be used in making building brick, some being suitable also for tile and face brick.

It is apparent that the progress of the investigation of Florida clays would be much facilitated if the State Survey could have its own testing plant. This applies not only to tests of clays for paving brick but to the general study of clays for building and face brick and tile, and of kaolins for pottery purposes. At present space in which to install clay testing machinery is not available and the State Survey can not make its own clay tests until adequate office and laboratory space is provided. For the tests that are here reported the Survey is indebted, as already stated, to the co-operation of the United States Bureau of Standards.

REPORT ON SAMPLES.

The following report on individual samples will serve to illustrate the properties of the clays that have been tested. In reading these returns it is well to remember that the tests were made primarily to determine whether or not the clays would vitrify at temperatures practicable in commercial kilns. It is doubtless true that more favorable results may be obtained in many cases by the mixing of various clays; this, however, remains to be tested.

Sample No. 1, Jackson County. The clay works with some difficulty in the stiff mud condition; water of plasticity in per cent of dry weight, 40.80%; warped and cracked during the drying treatment; linear drying shrinkage in terms of wet length, 9.95%; linear burning shrinkage in terms of dry length, at 850 degrees C., 0.77% at 1010 C., 4.59%; at 1130 C., 6.60%; at 1250 C., 7.55%; color after burning, light red at lower temperature, changing to dark red at higher; per cent porosity, at 850 degrees C., 36.75%; at 950 C., 40.55%; at 980 C., 34.30%; at 1010 C., 30.30%; at 1040 C., 24.20%; at 1070 C., 24.00%; at 1100 C., 26.10%; at 1130 C., 25.15%; at 1160 C., 23.65%; at 1190 C., 23.60%; at 1220 C., 23.85%; at 1250 C., 20.70%. A somewhat plastic and sticky clay of high drying and burning shrinkage. The clay retains a porous structure at 1250 degrees C. (2282 degrees F.), and cannot be used in the manufacture of vitrified ware burned in commercial kilns. The clay may be used in the manufacture of common and building brick.

Sample No. 2, *Washington County.* The clay possesses good working plasticity and molding behavior; water of plasticity, 36%; a few cracks developed by drying; linear drying shrinkage, 9.42%; linear burning shrinkage, at 850 degrees C., 0.55%; at 1010 C., 1.57%; at 1130 C., 7.75%; at 1250 C., 8.10%. A good light buff color is developed by burning; per cent porosity, at 850 degrees C., 36.80%; at 950 C., 35.30%; at 980 C., 34.75%; at 1010 C., 34.50%; at 1040 C., 30.75%; at 1070 C., 25.70%; at 1100 C., 22.45%; at 1130 C., 19.70%; at 11.60 C., 17.95%; at 1190 C., 15.70%; at 1220 C., 14.60%; at 1250 C., 12.55%. A buff burning clay of good plasticity and a relatively high drying shrinkage. May be used in the manufacture of buff colored face brick, although care must be exercised in drying. The clay must be burned above 1250 degrees C. in order to attain low porosity.

Sample No. 3, *Santa Rosa County.* The clay has good working plasticity and molding properties; water of plasticity, 28.90%; no drying difficulties; linear drying shrinkage, 6%; linear burning shrinkage, at 850 degrees C., 0.64%; at 1010 C., 0.21%; at 1130 C., 1.44%; at 1250 C., 1.17%; burns to salmon color, changing to buff at higher temperature; per cent porosity, at 850 degrees C., 35.30%; at 950 C., 35.80%; at 980 C., 36.20%; at 1010 C., 34.86%; at 1040 C., 33.60%; at 1070 C., 32.15%; at 1100 C., 31.10%; at 1130 C., 29.55%; at 1160 C., 29.05%; at 1190 C., 28.80%; at 1220 C., 28.05%; at 1250 C., 27.30%. A clay possessing good working and drying qualities but which cannot be vitrified at the burning temperatures of commercial kilns. Test pieces burned to 1250 degrees C. are easily cut by a knife. This clay is of value only in the manufacture of porous common building brick, etc.

Sample No. 4, *Escambia County.* Appears to have good working behavior and plasticity; water of plasticity, 21.95%; drying behavior satisfactory; linear drying shrinkage, 5.75%; linear burning shrinkage, at 850 degrees C., 1.28%; at 1010 C., 0.05%; at 1130 C., 0.26%; at 1250 C., 1.16%; color after burning, light to dark red; per cent porosity, at 850 C., 28.65%; at 950 C., 29.30%; at 980 C., 28.20%; at 1010 C., 27.90%; at 1040 C., 27.75%; at 1070 C., 25.85%; at 1100 C., 26.95%; at 1130 C., 25.70%; at 1160 C., 27.95%; at 1190 C., 26.80%; at 1220 C., 19.90%; at 1250 C., 20.20%. A clay possessing good working and drying behavior, but one which retains a porous structure at temperatures as high as 1250 degrees C. The clay is suitable for common and face brick, etc., but not for paving brick or other vitrified ware.

Sample No. 5, *Walton County.* Plasticity and working properties good; water of plasticity, 28.30%; drying behavior satisfactory; linear drying shrinkage, 6.75%; linear burning shrinkage, at 850 degrees C., 0.34%; at 1010 C., 0.35%; at 1130 C., 2.17%; at 12.50 C., 2.25%; color after burning, salmon to light red; per cent porosity, at 850 degrees C., 33.60%; at 950 C., 33.20%; at 980 C., 35.40%; at 1010 C., 34.35%; at 1040 C., 32.80%; at 1070 C., 30.50%; at 1100 C., 29.85%; at 1130 C., 28.60%; at 1160 C., 27.55%; at 1190 C., 27.80%; at 1220 C., 27.10%; at 1250 C., 26.00%. A red burning clay having good working and drying behavior, but retaining a porous structure. Test pieces burned to 1250 C. are easily scratched by a knife. This clay is suitable for the manufacture of porous common and building brick. Not practical to vitrify in commercial kilns.

Sample No. 11, *Duval County.* Fairly plastic, fairly good working qualities;

water of plasticity, 27.4%; dries satisfactorily; linear drying shrinkage, 9.6%; linear burning shrinkage, at 990 degrees C., 0.05%; at 1110 C., 0.82%; at 1230 C., 2.34%; at 1320 C., 3.97%; red burning; per cent porosity, at 850 degrees C., 28.1%; at 950 C., 26.8%; at 980 C., 25.7%; at 1010 C., 25.8%; at 1040 C., 24.8%; at 1070 C., 24.6%; at 1100 C., 22.5%; at 1130 C., 22.5%; at 1160 C., 20.4%; at 1190 C., 16.6%; at 1220 C., 11.5%; at 1250 C., 7.5%. A sandy surface clay of fair working and drying behavior. A decrease in porosity is noted with increase in temperature, although it is doubtful whether a vitrified product may be manufactured from this material, owing to the relatively high temperatures necessary.

Sample No. 12, *Clay County*. Very plastic and possesses fair working qualities; water of plasticity, 34.4%; excessive drying shrinkage; linear drying shrinkage, 12.22%; linear burning shrinkage, at 990 degrees C., 1.45%; at 1110 C., 3.48%; at 1230 C., 4.87%; red burning; per cent porosity, at 850 degrees C., 24.4%; at 950 C., 22.7%; at 980 C., 19.6%; at 1010 C., 18.7%; 1040 C., 18.7%; at 1070 C., 17.4%; at 1100 C., 17.3%; at 1130 C., 16.8%; at 1160 C., 16.9%; at 1190 C., 16.6%; at 1220 C., 14.4%; at 1250 C., 13.8%. A plastic red burning clay having a high drying shrinkage. Care must be exercised in drying heavy pieces. This clay has a relatively low porosity at commercial kiln temperatures and attains a fairly dense structure.

Sample No. 21, *Jefferson County*. Medium plastic with fair working properties; water of plasticity, 32.6%; no drying difficulties; linear drying shrinkage, 9.77%; linear burning shrinkage, at 990 degrees C., 0.22%; at 1110 C., 1.09%; at 1230 C., 0.55%; at 1320 C., 0.49%; buff burning; per cent porosity, at 990 degrees C., 35.6%; at 1020 C., 34.0%; at 1050 C., 33.2%; at 1080 C., 33.4%; at 1110 C., 33.8%; at 1140 C., 33.6%; at 1170 C., 33.6%; at 1200 C., 33.7%; at 1230 C., 32.8%; at 12.60 C., 34.4%; at 1290 C., 33.7%; at 1320 C., 33.5%. A sandy buff burning clay which retains an open porous structure at temperatures up to 1320 degrees C. (2408 degrees F.). May have some use in the manufacture of soft porous common building brick.

Sample No. 22, *Polk County*. Medium plastic with fair working properties; water of plasticity, 24.9%; no drying difficulties; linear drying shrinkage 6.28%; linear burning shrinkage, at 950 degrees C., 0.37%; at 1100 C., 0.47%; at 1220 C., 0.08%; at 1310 C., 0.24%; burns red; per cent porosity, at 950 degrees C., 35.6%; at 1010 C., 35.8%; at 1040 C., 35.6%; at 1070 C., 36.0%; at 1100 C., 34.8%; at 1130 C., 33.8%; at 1160 C., 33.8%; at 1190 C., 33.7%; at 1220 C., 33.6%; at 1250 C., 33.7%; at 1280 C., 33.4%; at 1310 C., 33.6%. A sandy red burning material which retains an open porous structure at temperatures up to 1320 degrees C. May have some use in the manufacture of soft porous common building brick.

FULLER'S EARTH.

The total production of fuller's earth in the United States during 1914 was 40,981 short tons, an increase over the preceding year of 2.387 tons. In addition to that produced, there was imported into the United States during the year 22,302* short tons, a substantial increase over the imports of the preceding year. Some fuller's earth is exported from the United States, although the amount can not be determined owing to the fact that this product is not listed separately from other clays.

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*From quarterly statement of imports, U. S. Department of Commerce, Bureau of Foreign and Domestic Commerce.

Florida is the chief producer of fuller's earth in the United States, more than 75% of the total production during 1914 being credited to that State. The other states which contributed to the total output during 1914 were Arkansas, California, Colorado, Georgia, Massachusetts, and Texas. The production in Florida, although not separately listed, is included in making up the total mineral production of the State. The fuller's earth of Florida is used chiefly in clarifying mineral oils, although some is being prepared also for vegetable oils.

The following companies are engaged in mining fuller's earth in Florida: The Atlantic Refining Company, Ellenton; the Floridin Company, Quincy, and Jamieson; the Florida Fuller's Earth Company, Ellenton; and the Fuller's Earth Company, Midway.

LIME.

The total quantity of quick and hydrated lime made in Florida during 1914 amounted to 12,376 tons, valued at $64,531. The companies reporting production of lime in Florida during 1914 were as follows:

Florida Lime Company, Ocala, Florida.
Live Oak Limestone Company, Live Oak, Florida.
Marion Lime Company, Ocala, Florida.
Standard Lime Company, Kendrick, Florida.

PRODUCTION OF PHOSPHATE ROCK IN FLORIDA DURING 1914.*

Owing to the interruption of European shipment the production of phosphate rock in Florida for the year 1914 shows a decrease over that of the preceding year. The output for 1913 was 2,584,794 long tons, while during 1914 the output, as reported by the producers, was 2,097,864 long tons, a decrease of 486,930 tons. The decrease occurred in both the land pebble and the hard rock districts; the percentage of decrease, however, is greater for the hard rock phosphate deposits. That the reduced output is due to the interruption of foreign shipment is shown by the fact that while the export shows a marked decrease, the amount of phosphate consigned for domestic shipments during 1914 is greater than during 1913, by about 28,918 tons.

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*First published as advance statement, April 30, 1915.

The total shipment of phosphate rock for 1914 as reported by the producers was 2,138,891 long tons, of which 1,829,202 tons were land pebble (including a small consignment of river pebble), and 309,689 tons were hard rock phosphate. The river pebble included in the shipments represents rock on hand from previous years, as no river pebble is being produced at present. Of the total shipments, 928,993 tons were consigned for export, while 1,209,898 tons were consigned for domestic use within the United States. The export shipments were made up of land pebble 625,821 tons, hard rock 303,172 tons. The domestic shipments consisted of land pebble 1,203,381 tons, hard rock 6,517 tons.

The production of land pebble phosphate was 1,787,597 tons as against 2,107,256 tons during the preceding year, a reduction of 319,659 tons. The production of hard rock phosphate during 1914 was 310,267 tons, as against 477,538 tons during the preceding year, a reduction of 167,271.

SUMMARY OF PRODUCTION AND SHIPMENT OF PHOSPHATE IN FLORIDA FOR THE YEAR 1914, BASED ON DATA SUPPLIED BY THE PRODUCERS.

	Long Tons.
Pebble Phosphate—	
Production	1,787,597
Consigned for export	625,821
Consigned for domestic shipment	1,203,381
Total shipments	1,829,202
Hard Rock Phosphate—	
Production	310,267
Consigned for export	303,172
Consigned for domestic shipment	6,517
Total shipments	309,689
Pebble and Hard Rock Phosphate Combined—	
Production	2,097,864
Consigned for export	928,993
Consigned for domestic shipment	1,209,898
Total shipments	2,138,891

The value of the phosphate shipped from Florida during 1914 was as follows: Land pebble, including a limited amount of river pebble, $5,442,547; hard rock, $1,912,197. Total, $7,354,744.

The following is a list of the phosphate mining companies of Florida. Of the companies on this list a few were idle in 1914; most of these, however, carried rock in stock from which sales were made, and will continue operations when conditions are favorable.

The number of companies that actually produced phosphate rock in Florida during 1914 was twenty-five. Of these fourteen mined land pebble phosphate and eleven mined hard rock phosphate.

LIST OF THE PHOSPHATE MINING COMPANIES OF FLORIDA.

Acme Phosphate Co.	Morriston, Fla.
Amalgamated Phosphate Co.	25 S. Calvert St., Baltimore, Md., and Chicora, Fla.
Armour Fertilizer Works	Bartow, Fla., and Union Stock Yards, Chicago, Ill.
P. Bassett (Successor to Central Phosphate Co.)	Newberry, Fla.
Peter B. and Robert S. Bradley	92 State St., Boston, Mass., and Floral City, Fla.
J. Buttgenbach & Co.	Holder, Fla.
C. & J. Camp	Ocala, Fla.
Charleston, S. C., Mining and Manufacturing Co.	Richmond, Va., and Ft. Meade, Fla.
Compagnie Generale des Phosphates de la Floride	Paris, France, and Pembroke, Fla.
Coronet Phosphate Co.	Lakeland, Fla., and 99 John St., New York.
Cummer Lumber Co.	Jacksonville and Newberry, Fla.
Dominion Phosphate Co.	Bartow, Fla.
Dunnellon Phosphate Co.	Rockwell, Fla.
Dutton Phosphate Co.	Gainesville, Fla.
Export Phosphate Co.	Mulberry, Fla., and 53 State St., Boston, Mass.
Florida Mining Co.	165 Broadway, New York, and Mulberry, Fla.
Florida Phosphate Mining Corporation	Norfolk, Va., and Bartow, Fla.
Franklin Phosphate Co.	Newberry, Fla.
Holder Phosphate Co.	Ocala and Inverness, Fla.
International Phosphate Co.	27 State St., Boston, Mass., and Ft. Meade, Fla.
Interstate Chemical Corporation	Charleston, S. C., and Bowling Green, Fla.
Istachatta Phosphate Co.	Istachatta, Fla.
Lakeland Phosphate Co.	Lakeland, Fla.
Mutual Mining Co.	Savannah, Ga., and Floral City, Fla.
Meredith-Noble Phosphate Co.	Romeo, Fla.
Palmetto Phosphate Co.	Baltimore, Md., and Tiger Bay, Fla.
Peace River Phosphate Co.	Arcadia, Fla.
Pebbledale Phosphate Co.	Mulberry, Fla.
Phosphate Mining Co.	55 John St., New York, and Nichols, Fla.
Pierce Phosphate Co.	2 Rector St., New York, and Pierce, Fla.
Prairie Pebble Phosphate Co.	165 Broadway, New York, and Mulberry, Fla.
Schilmann & Bene	Ocala, Fla.
Societe Franco-Americaine des Phosphates de Medulla (Successor to Standard Phosphate Co.)	Christina, Fla.
Southern Phosphate Development Co.	Ocala and Inverness, Fla.
T. A. Thompson	Ft. White, Fla.
Swift & Co.	Bartow, Fla.

SUMMARY OF PRODUCTION AND SHIPMENT OF FLORIDA PHOSPHATE FOR THE YEARS 1908, 1909, 1910, 1911, 1912, 1913 AND 1914 (LONG TONS).

	1909.	1910.	1911.	1912.	1913.	1914.
Pebble Rock—						
Production	1,334,569	1,637,709	2,020.478	2,043,486	2,107,256	1.787,597
Exported	509,341	606,110	703,589	732,651	887,398	625,821
Domestic	819,701	995,728	1,274,056	1,204,502	1,168,084	1,203,381
Total shipments	1,329,042	1,601,838	1,977,645	1,937,153	2,055,482	1,829,202
Hard Rock—						
Production	527,582	392,088	474,094	536,379	477,538	310,267
Exported	496,645	461,353	462,072	470,354	476,898	303,172
Domestic	17,456	18,745	16,723	15,425	12,896	6.517
Total shipments	514,101	480,098	478,795	485,779	489,794	309,689
Pebble and Hard Rock Combined—						
Production	1,862,151	2,029,797	2,494,572	2,579,865	2,584,794	2,097,864
Exported	1,005,986	1,067,463	1,165,661	1,203,005	1,364,296	928,993
Domestic	837,157	1,014,473	1,290,779	1,219,927	1,180,980	1,209,898
Total shipments	1,843,143	2,081,936	2,456,440	2,422,932	2,545,276	2,138,891

Total phosphate produced in Florida 1908 to 1914 inclusive	15,567,054
Total phosphate exported 1908 to 1914 inclusive	7,836,675
Total domestic shipments 1908 to 1914 inclusive	7,184,895
Total recorded shipments 1908 to 1914 inclusive	15,021,570
Total amount of phosphate produced in Florida from the beginning of mining in 1888 to 1914 inclusive	27,962,785

SAND AND GRAVEL.

The sand produced in Florida is used chiefly for building purposes, although a limited amount is used as moulding sand. The gravel produced finds its chief use for road-making and road ballast. The total production of sand and gravel for 1914 was 177,241 tons, valued at $54,120.00. Of this amount 98,435 short tons, valued at $10,637.00, was gravel, the balance being sand of the grades mentioned.

The companies reporting the production of sand and gravel in Florida during 1914 are the following:

Atlantic Coast Line Railroad Company.
Florida Sand and Shell Company, Tampa, Fla.
Interlachen Gravel Company, Interlachen, Fla.
Logan Coal and Supply Company, Jacksonville, Fla.
W. E. Long, Orlando, Fla.
R. L. Martin, Ocala, Fla.
Walter L. Wescott, Orlando, Fla.
Woodmar and Company, Ocala, Fla.

SAND-LIME BRICK.

The materials used in the manufacture of sand-lime brick are sand and lime. The bonding power of the brick is due to the chemical reaction between these ingredients. The chemical changes occur in presence of heat, pressure and moisture and result in the formation of hydro-silicates of calcium and magnesium.

The sand used in the manufacture of sand-lime brick should be comparatively pure and preferably with some variation in the size of the grains. The mixture of lime, sand and water, is cut in the form of bricks and conveyed to a hardening cyclinder. Necessary heat and pressure are obtained in the hardening cyclinder adapted for the purpose. The sand-lime bricks are placed in this cyclinder and subjected to a pressure and temperature which vary according to the method of treatment.

Four companies were actively engaged in the manufacture of sand-lime brick in Florida during 1914 as follows: The Bond Sandstone Brick Company, Lake Helen, Fla.; The Composite Brick Company, 425 St. James Bldg., Jacksonville, Fla.; Plant City Composite Brick Company, Plant City, Fla.. and the Valrico Sandstone Company, Valrico, Fla.

The total production of sand-lime brick in Florida during 1914 was valued at $105,435.00. This is an increase of $25,756.00 in value over that of 1913.

WATER.

The springs of Florida are famous for their large volume of flow as well as for the clearness and beauty of their waters. Many of these springs are used as health resorts, while from others the water is sold for medicinal or table use. The total sales of mineral and spring water in Florida during 1914, as shown by the returns from the owners of springs and wells, amount to 231,160 gallons, valued at $24,738. The average price thus approximates ten cents per gallon. The total sales are divided as follows: Medicinal waters, $3,315; table waters, $21,423.

The following is a list of those who report having sold spring or well water during 1914, together with the name of the spring or well from which taken:

Chumuckla Mineral Springs and Hotel Company, Chumuckla Mineral Springs, Chumuckla, Florida.
Espiritu Santo Springs Company, Espiritu Santo Springs, Safety Harbor, Florida.
Lackawanna Water and Ginger Ale Company, Lackawanna Springs, Jacksonville, Florida.
L. H. McKee, Quisisana Spring, Green Cove Springs, Florida.
Magnesia Spring Water Company, Magnesia Spring, Grove Park, Florida.
Magnolia Springs Hotel Company, Magnolia Spring, Magnolia Springs, Florida.
Nathaniel Brewer, Jr., Newport Springs, Newport, Florida.
Orange City Mineral Springs Company, Orange City Mineral Springs, Orange City, Florida.
Panacea Springs Company, Panacea Springs, Panacea, Florida.
Ponce de Leon Springs Corp., DeLeon Springs, DeLeon Springs, Florida.
Purity Springs Water Company, Purity Spring, Tampa, Florida.
Tampa Kissengen Well's Company, Stomawa Mineral Well, Tampa, Florida.
Vincent Bros., Wekiva Springs, Apopka, Florida.

SUMMARY STATEMENT OF MINERAL PRODUCTION IN FLORIDA DURING 1914.

Common or building brick, 41,901 M., valued at	$ 230,377.00
Lime, including quick and hydrated lime, 12,376 tons, valued at	64,531.00
Limestone, including ground limestone for agricultural use and crushed rock for railroad ballast, concrete and road material	343,779.00
Mineral waters, 231,160 gallons, valued at	24,738.00
Phosphate rock, 2,097,864 long tons, valued at	7,354,744.00
Sand and gravel, including building and moulding sand and gravel, 177,241 short tons, valued at	54,120.00
Sand-lime brick, including common and front brick, 18,476 thousand, valued at	105,435.00
Mineral products not separately listed, including ball clay, drain tile, vitrified block, diatomaceous earth, fuller's earth	443,964.00
Total mineral production valued at	$8,621,688.00

THE PEBBLE PHOSPHATES OF FLORIDA.

BY E. H. SELLARDS.

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THE PEBBLE PHOSPHATES OF FLORIDA.

E. H. SELLARDS.

The phosphates of Florida are known commercially as hard rock, land pebble, and river pebble. An explanation of the origin of the hard rock phosphate was suggested by the writer in a paper published in 1913*. The present paper relates to the origin, location and conditions of deposition of the land and the river pebble deposits of the State.

LOCATION OF DEPOSITS.

The land pebble phosphate deposits of Florida known to be workable are found in southern Florida, in Hillsboro, Polk and DeSoto counties. The belt of country in which mines are now operating extends from near Plant City on the north to near Bowling Green on the south, a distance in a north-west to south-east direction of approximately thirty miles. The width of the productive belt probably nowhere exceeds ten or fifteen miles. The formation, of which these workable beds are a part, has, however, as will be shown, a much greater extent.

The term river pebble is applied to phosphates that have accumulated along streams. The best known of the river pebble deposits and the only ones that have been worked commercially are those found in the valley of the Peace River in DeSoto County and in the valley of the Alafia River in Hillsboro County, although smaller deposits are known at many other localities in the State.

The hard rock phosphate deposits are found in north central Florida forming a belt paralleling the Gulf Coast for a distance of about 100 miles. The approximate location of the different types of phosphate in Florida is shown on the accompanying outline map.

Phosphate mining in Florida was begun on Peace River in 1888, the first rock produced being river pebble; in that year, also, the hard rock phosphates were discovered and were rapidly developed. Production of land pebble phosphate in Florida was begun probably in 1890, the first shipment having been made in 1891. No river pebble is now being mined in Florida; of the hard rock phosphate the output for some years past has approximated one-half million tons per annum, while of land pebble, the production at the present time under normal conditions is in excess of two million tons per annum.

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*Fla. State Geol. Surv., 5th Ann. Rept., pp. 23-80, 1913.

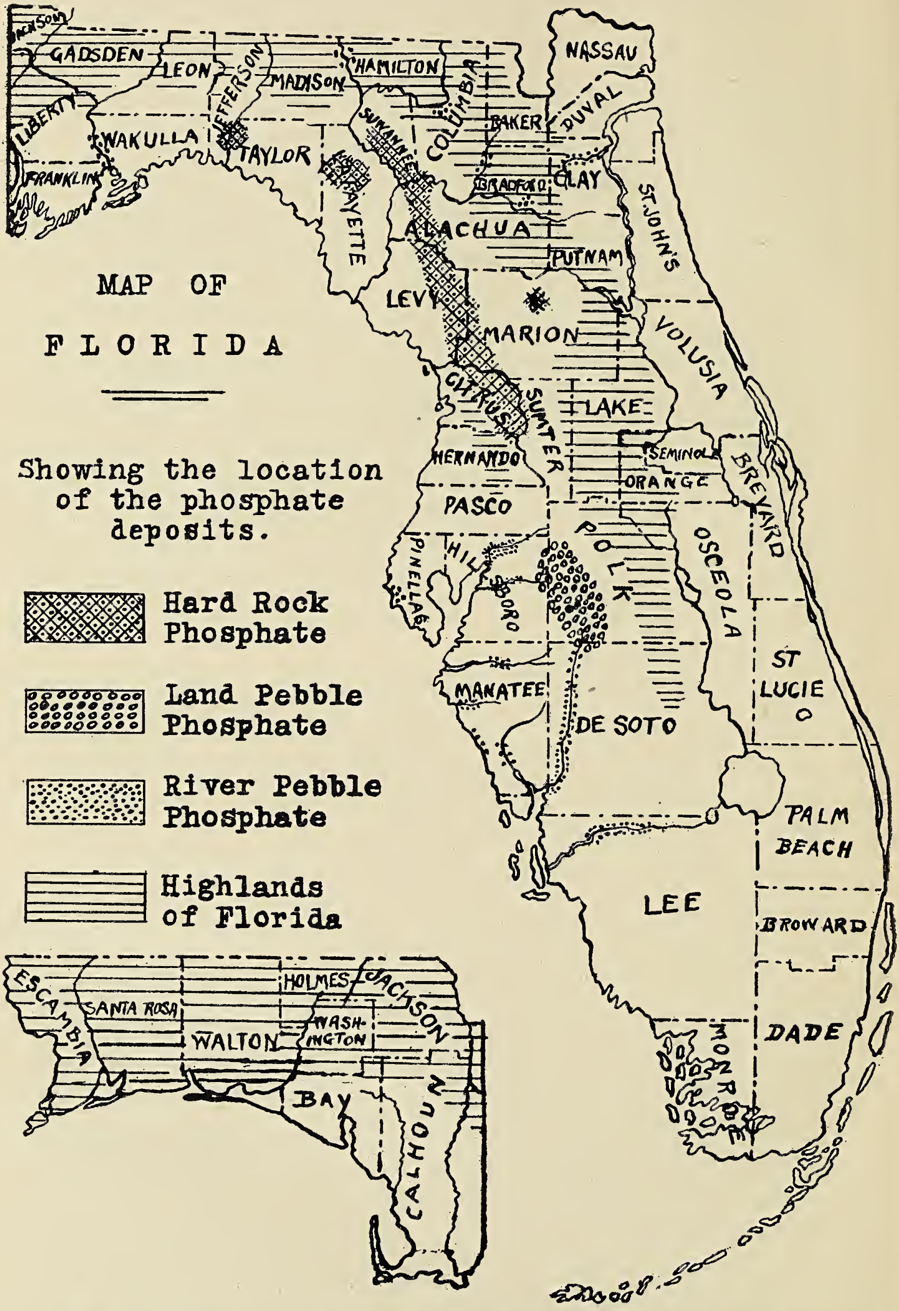

Fig. 1.—Sketch map of Florida showing the location of phosphate deposits.

PROBLEMS TO BE ACCOUNTED FOR.

Among the problems to be accounted for in connection with the origin of the pebble phosphate deposits are the following: (1). The source of the phosphate pebble found in the land and river phosphate deposits. (2). The source of the materials of the matrix, including sand, clay, vertebrate, invertebrate and plant fossils. (3) The conditions under which the formation accumulated. (4). The minor problems of the formation, such as variation in grade of rock, irregularities in the beds, lack of continuity of the deposits, variation in the thickness of the phosphate stratum and in the richness of the matrix. While all of the many perplexities met with in mining may not be explained in this report, it is believed that there is presented here a rational basis from which the causes of many of the seemingly erratic variations in the phosphate beds may be understood.

SUMMARY OF THE EXPLANATION OFFERED.

The explanation offered, briefly summarized, is as follows: The land pebble phosphate bed is a conglomerate of pebble, sand and clay formed by the sea advancing probably with minor oscillations in level across the exposed surface of the great phosphatic marl known to the miners as the "bed rock." The immediate source of the phosphate rock as well as the other materials of the matrix is therefore from the "bed rock" marl. The sands of the overburden represent the part of the formation that was deposited following the accumulation of the pebble conglomerate. Within the phosphate bed the grade of rock is enhanced through secondary enrichment brought about by the agency of surface waters moving downward and laterally through the formation. The minor variations in structure in the beds find their explanation in the varying conditions that prevail in shallow water deposits. The fossils in the phosphate deposits are derived in part from the earlier formations, and in part represent animals that were living at the time the deposits accumulated. The original source of the phosphorus is the primitive rocks of the earth's crust through which it is widely disseminated and from which it finds its way into sedimentary rocks by diverse processes, some of which have been enumerated by the writer in an earlier paper of this series.* The river pebble deposits were accumulated in the beds of streams during either Pleistocene or recent time, the pebble having been washed out of the older formations.

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*Fla. State Geol. Surv., Sixth Ann. Rept., pp. 71-81, 1914.

GEOLOGY OF SOUTHERN FLORIDA.

If the origin of the phosphate deposits is to be understood it becomes necessary first of all to obtain a clear conception of the geology of the country in which they are found. The areal and structural geology of southern Florida is now known with a reasonable degree of completeness and from this may be deduced the geological history. The formations exposed at the surface in this part of the State include the following: The Tampa and Alum Bluff formations which are of Oligocene age; the Bone Valley formation, which contains the land pebble phosphates and is of Pliocene, or possibly late Miocene age; and the Peace Creek beds which contain the river pebble phosphates, and are of Pleistocene age. The Ocala limestone although not seen at the surface in southern Florida, as it lies buried to a considerable depth by these later formations, has nevertheless an important relation to the phosphate industry since it is reached by all the deep wells of the region, and from it chiefly is obtained the water supply for hydraulic mining.

It is a pleasure to acknowledge in this connection the credit that is due those whose investigations have contributed to a knowledge of the geology of southern Florida. Among these should be mentioned in particular Allen (1846), Conrad (1846), Tuomey (1850), Smith (1881), Heilprin (1887), Dall (1890-1903, 1915), Eldridge (1893), Shaler (1893), Matson and Clapp (1909) and Vaughan (1910). Without the knowledge of the general geology of Florida, to which these writers have contributed, an explanation of the origin of the pebble phosphate deposits could not be given at this time.

A bibliography of the geology of Florida may be found in the First Annual Report of the State Survey pp. 54-108. In addition the papers relating specially to the phosphates of Florida are listed and reviewed in the Fifth Annual Report of the State Survey, pp. 67-80, 1913.

STRATIGRAPHIC SUCCESSION.

EOCENE.

OCALA FORMATION.

Of the formations mentioned the Ocala is the earliest or oldest, being probably of Eocene age.* This formation consists largely of very pure and for the most part light colored limestones which have been fully described in the earlier reports of the State Survey. These limestones lie at or near the surface over a large area in west central Florida, the hard rock phosphate resting upon them, as explained in the writer's paper relating to those deposits. To the south, north and east of the hard rock phosphate area and probably to the west also the Ocala passes beneath the surface. In Sumter County limestones of the Ocala formation are seen as far south as Panasoffkee and as far east as Wildwood. In Hernando County these limestones are seen somewhat south of Croom. The southward dip of the formation is further indicated by the fact that at Tiger Bay in Polk County the Ocala is first encountered at a depth of at least 360 feet. That the formation dips to the east has been shown by numerous well records.

OLIGOCENE.

THE TAMPA FORMATION.

The Tampa formation which consists chiefly of impure clayey limestones together with notable flint beds, is well exposed along the Hillsboro River at and above Tampa and on Hillsboro Bay. The silicified beds of this formation exposed at Ballast Point and elsewhere on Tampa Bay have received the name of the Tampa Silex beds, while the limestone and marls of the formation in the vicinity of Tampa are known as the Tampa limestone. In general the Tampa limestone may be expected to dip in passing to the south and east. This is doubtless true although the formation is with dif-

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*Unpublished manuscript of C. W. Cooke and R. S. Bassler. As early as 1888 Mr. Joseph Willcox obtained Zeuglodont remains from the Ocala limestone at Ocala. A second specimen of a Zeuglodont was obtained at Ocala in 1913 by C. W. Cooke of the U. S. Geological Survey and Herman Gunter of the Florida Geological Survey. In 1914 the writer obtained through Mr. Franz Weston from pit No. 12 of the Cummer Lumber Company near Newberry some whale vertebrae which have been determined bv J. W. Gidley as *Basilosaurus brachyspondylus.* Mr. Gidley adds that the specimen should be of Eocene age (Letter of Nov. 11, 1914).

ficulty recognized from well samples. The term Tampa formation is here used as defined in the Second Annual Report of this Survey, 1909.

With regard to the exact equivalence in the Oligocene series, of the Tampa Silex beds and the Tampa limestone, there may be as yet some doubt. In their study of the geology and stratigraphy of Florida published in the Second Annual Report of the State Survey, 1909, Messrs. Matson and Clapp expressed the view that the Tampa formation of southern Florida is contemporaneous with the Chattahoochee formation of the Apalachicola River section. This view is supported also by Vaughan*. Dr. W. H. Dall, however, is of the opinion that the Tampa limestone is of later age than the Chattahoochee limestone.† While the determination of the relation of these beds is of importance in the study of the stratigraphy of Florida, the problem does not enter essentially into the study of the phosphate deposits. For this reason the correlation of these formations will not be further discussed at this time, since for the present it is sufficient to recognize that the Tampa formation, as the term is here used, represents the earliest upper Oligocene deposits of southern Florida.

THE ALUM BLUFF FORMATION.

The Alum Bluff formation in Florida represents the uppermost or latest of the Oligocene series. As now understood the formation is a very extensive one reaching from the Apalachicola River in west Florida, east and south through the peninsula to the Gulf, forming a broad belt lying north and east of the older formations previously described.

The relation of the Alum Bluff formation to the Chattahoochee limestone of northern Florida as well as to the Tampa limestone of southern Florida is probably throughout that of conformity, the change from the one formation to the other being gradual. The Alum Bluff, however, contains a larger amount of sand and clay than do the other formations, thus indicating a marked change in the conditions of deposition. Another notable feature of the Alum Bluff formation to which reference will be made later, is the fact that it contains throughout more or less phosphatic material. The formation is of special interest in connection with the pebble phosphate from the fact that it forms the bed rock of the phosphate mines and, as will be subsequently shown, is the parent formation from which the pebble phosphate deposits were derived.

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*Vaughan, T. W., a contribution to the Geologic History of the Floridian Plateau. Carnegie Institution of Washington, Publication No. 133, pp. 99-185, 1910.

†Dall, W. H., U. S. Geol. Surv. Bull. 84, 1892; Wag. Free Inst. Sci., Vol. 3, Pt. 6, 1903; U. S. National Museum Bull. 90, 1915.

The type locality of the Alum Bluff formation is at Alum Bluff on the Apalachicola River. At this place the Alum Bluff consists chiefly of gray phosphatic and calcareous sands. Among the detailed sections on the Apalachicola River described by the writer and Herman Gunter in the Second Annual Report of this Survey were the following:

Section at Rock Bluff.

Rock Bluff lies five and one-half miles in a direct line south of southwest of Aspalaga Bluff, or twelve and one-half miles from the State line. It is the second point at which the river in Florida strikes the east border of the river valley. That part of Rock Bluff which faces the river lies near the southwest corner of Section 17, R. 7 west, T. 2 north. The basal part of the following section is made near the north end where the river channel first strikes the bluff. From this point the level was transferred north across a small stream to that part of the bluff which does not now directly face the river.

		Thickness of stratum.	Height above river (stage of Mar. 5, 1909).
11.	Covered in the line of the section to the top of the bluff from the river, about ¼ mile	100 feet	100 to 200 feet.
10.	Fuller's earth (exposed)	3 feet	97 to 100 feet.
9.	Ledge with shells	1 foot	96 to 97 feet.
8.	Gray sand	5 feet	91 to 96 feet.
7.	Ledge with shells	2 feet	89 to 91 feet.
6.	Gray sand with lime inclusions	5 feet	84 to 89 feet.
5.	Covered	2 feet	82 to 84 feet.
4.	Light gray calcareous sand containing a trace of phosphate (by transferring the level across a small branch to the north the section is continued)	30 feet	52 to 82 feet.
3.	Bluish green to gray sands, variable in character. Lime inclusions begin to appear in these sands at 20 feet from the base. These become more numerous until the material passes gradually into the sandy-marl above	34 feet	18 to 52 feet.
2.	Compact sandy marl with concretions near the base and with an ostrea layer 6 feet above the base	8 feet	10 to 18 feet.
1.	Chattahoochee limestone above water level	10 feet	0 to 10 feet.

While the dividing line between the Chattahoochee limestone and the Alum Bluff formation is not well marked, it is probable that in this section about 90 feet of the Alum Bluff formation is exposed including Nos. 2 to 10 of the section.

Section at Alum Bluff, Liberty County.

The following section was made at Alum Bluff a short distance north of the middle of the bluff at a point where a recent landslide (reported to have occurred in 1905 or 1906) has left the bluff bare of vegetation. The measurements of this section were made by hand level.

		Thickness of stratum.	Height above river (stage of Mar. 5, 1909).
8.	Pale yellow incoherent sand	30 feet	136 to 166 feet.
7.	Reddish and purple sands and sandy clays partly covered toward the base	70 feet	66 to 136 feet.
6.	Covered	6 feet	60 to 66 feet.
5.	Dark colored sandy non-fossiliferous clays, in places tasting of alum	17 feet	43 to 60 feet.
4.	Dark or gray marls, highly fossiliferous	14 feet	29 to 43 feet.
	Unconformity.		
3.	Laminated and cross bedded sands and clays, and blue sands; in places absent	3 feet	26 to 29 feet.
	Apparent unconformity.		
2.	Light gray calcareous sands or sandstone	16 feet	10 to 26 feet.
1.	Sands, slightly indurated and weathering yellow upon exposure	10 feet	0 to 10 feet.

The light gray sandstone (No. 2) of this section is apparently the same as No. 4 of the Rock Bluff section, the stratum having been recognized at several intermediate localities along the river bluff between the two localities and on tributaries entering the river. Samples from this stratum gave the following analyses. No. 1 is from Rock Bluff (No. 4 of the section). No. 2 is from Alum Bluff (No. 2 of the section). No. 3 from an exposure on a tributary to Sweet Water Creek Sec. 5, T. 1 N., R. 7 W. All samples were collected by the writer.

Analyses made for the State Survey in the office of the State Chemist, B. H. Bridges, Analyst.

	No. 1.	No. 2.	No. 3.
Silica (SiO_2)	48.44	53.02	34.03
Calcium carbonate ($CaCO_3$)[1]	38.57	38.57	35.35
Magnesium carbonate ($MgCO_3$)[1]	1.68	1.84	26.00
Iron and Alumina (Fe_2O_3 and Al_2O_3)	2.88	3.96	3.20
Phosphoric acid (P_2O_5)	Trace	0.22	Trace
Sulphate (SO_4)	Trace	Trace	Trace
Moisture (100 degrees F.)	1.37	1.60	1.32

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[1] Calculated from the oxides. No. 1, Calcium oxide, 21.60; magnesium oxide, 0.80. No. 2, Calcium oxide, 21.60; magnesium oxide, 0.88. No. 3, Calcium oxide, 19.80; magnesium oxide, 12.39.

Above this stratum at Rock Bluff is found gray and blue sands leading up to the workable fuller's earth stratum. At Alum Bluff the fuller's earth fails to appear, and the top surface of the calcareous sand stratum is irregular as if by erosion. In some parts of the bluff fossiliferous Miocene marl rests directly upon these sands. Usually, however, the calcareous sands are separated from the Miocene by laminated or cross bedded sands and clays often carrying vegetable remains. At Rock Bluff the calcareous sands have a total thickness of 30 feet. At Alum Bluff, owing to the irregular top surface, the thickness is variable. At one point near the middle of the bluff this stratum is lacking although elsewhere it has a thickness of 9 to 16 feet.

The cross bedded sands and laminated sands and clays lying above the calcareous sands are extremely variable in thickness, being not infrequently absent. They seem in fact merely to occupy irregularities in the top surface of the calcareous sands. An exposure about 300 feet from the north end of the bluff gives the following section:

Covered to the top of the hill.

Dark colored alum tasting clays	10 feet.
Fossiliferous Miocene marl	10 feet.
Unconformity.	
Laminated clays and sands with plant remains, and blue sands	7 feet.
Irregularity or unconformity.	
Calcareous sands	13 feet.
Sloping from the water's edge	15 feet.

A small stream enters just below this section. At this point is seen sands with buff colored clay partings, and plant remains, grading at the base into blue sands, having a total thickness of 8 feet. The greatest thickness observed, 21½ feet, is at a point near the middle of the bluff. * * * * The cross bedded sands here rest directly upon the fossiliferous Chipola beds, the calcareous sand stratum being as previously stated absent at this point.

In Gadsden County where the fuller's earth beds are worked, may be seen numerous partial sections of the Alum Bluff formation. The fuller's earth and the associated gray sands are also seen at Jackson Bluff and elsewhere on the Ocklocknee River between Gadsden and Leon Counties.

East of the Ocklocknee River in Wakulla County the Alum Bluff is believed to be represented by the gray phosphatic and calcareous stratum which has received the local name of the Sopchoppy limestone, exposures of which are found near the town of Sopchoppy. The red hills of Leon, Jefferson and Madison Counties with little doubt represent the Alum Bluff formation. Throughout these counties remnants of calcareous and phosphatic sandstones are found scattered through the partially disintegrated surface materials. Samples of this phosphatic sand rock taken near Tallahassee were found to contain from 34.3 to 37.47% tri-calcium phosphate. A sample taken two miles north of Monticello in Jefferson County was found to contain 40.45% tri-calcium phosphate. A sample of the calcareous and phosphatic marl taken from the property of C. A. Griscom near Lake Iamonia in Leon County at a depth of 10 feet below the surface gave the following analysis.

Analysis made by the State Chemist, L. Heimburger, analyst.

Moisture	22.73%
Insoluble matter	43.97%
Phosphoric acid (P_2O_5) 11.56, equivalent to tricalcium phosphate	25.27%
Calcium oxide (CaO) 5.06, equivalent to calcium carbonate	9.03%

In Hamilton County calcareous and phosphatic sands probably of this formation are found exposed in the sinks and along the stream beds west and north of Jasper. A limited amount of pebble phosphate derived from the same formation, is found in the stream beds at Jennings, near the State line. In Columbia County typical gray phosphatic and calcareous sands of the Alum Bluff formation are seen well exposed at Langston sink about four miles northwest of Lake City. A similar rock containing an abundance of light and dark colored phosphate pebble is found in Columbia and Bradford Counties on Olustee Creek near Lulu. Here also in the small streams tributary to Olustee Creek are found quite considerable secondary deposits of phosphate pebble derived from this rock. Another locality in Bradford County in which the phosphatic marls probably representing the Alum Bluff formation may be seen is the large sink near Brooker. The following section of this sink is from the writer's report on phosphates in the Second Annual Report of this Survey, pp. 239-240.

Section at the sink three miles southeast of Brooker.

13.	Covered and sloping	14	feet.
12.	Cream or light colored marl full of small shells	23½	feet.
11.	Yellowish sand matrix holding black pebble phosphate	5	feet.
10.	Sandy limestone ledge with fossils	¾	foot.
9.	Yellow sand matrix with pebble phosphate	4	feet.
8.	Concretionary limestone ledge	2¼	feet.
7.	Steel gray colored sand-clay oxidizing yellow	5	feet.
6.	Concretionary ledge containing pebble phosphate	1	foot.
5.	Sandy matrix with pebble phosphate	4	feet.
4.	Concretionary ledge	5	feet.
3.	Clayey matrix holding black pebble phosphate	5	feet.
2.	Concretionary ledge	1½	feet.
1.	Clayey matrix holding black pebble phosphate	4	feet.
	Total depth to the water's edge	75	feet.

The sink at which this section is made is circular in outline and is possibly 200 feet across. The depth of the sink to water level is 75 feet; the depth below water level has not been determined, although it is reported to be more than 100 feet. With the exception of the entrance of a small stream from the east the sides are almost perpendicular. This stream has cut its channel through to the hard ledge of stratum No. 4, over which it forms a waterfall. Strata numbers one to four of the section stand vertical entirely around the sink. The sands of numbers five to eight weather brownish in color, forming a conspicuous band surrounding the sink, except where cut across by the stream. The sands of number nine and eleven slope slightly from the lack of supporting ledges. The marl, number twelve, stands vertical or nearly so.

From its considerable thickness the phosphate pebble-bearing formation of this section may be expected to be found underlying a considerable area in this part of the State.

In this connection should be mentioned the phosphatic marls and limestones found on Black Creek in Clay County. This marl is identical in appearance with the similar phosphatic marls which underlie the land pebble phosphates. These beds on Black Creek, however, are regarded as of Miocene age, and correlated from the invertebrate fossils with the Jacksonville formation.

It may be of interest to note that the Black Creek phosphatic marls together with secondary pebble deposits derived from them were at one time worked to a limited extent by the late Governor N. B. Broward. The development of the deposits, however, was found not commercially practicable.

The phosphatic beds at Hawthorne which served originally as the type locality of the Hawthorne formation appear with little doubt to represent the Alum Bluff formation.* These beds are also found capping the hills in central Marion County.

In southern Florida the phosphatic marls believed to represent the Alum Bluff formation are found along Alafia River and thence east through Hillsboro and Polk Counties to Peace River, and probably lie comparatively near the surface as far east in Polk County as the margin of the lake region. In Manatee County these phosphatic marls are seen along Manatee River and its tributaries. On Little Sarasota Bay they are exposed at White Beach and on small streams entering the Gulf.

It is thus evident that the Alum Bluff formation underlies a large area in Florida. Its great thickness is shown by well records at Tiger Bay where it is found to be from 275 to 350 feet thick. Its south-eastward extent is indicated by well samples from Fort Myers as well as by the secondary deposits of pebble phosphates found along Coloosahatchee River and its tributaries.

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*Correlation of the Hawthorn Formation, by Thomas Wayland Vaughan and Charles Wythe Cooke, Journal of the Washington Academy of Sciences, Vol. IV, No. 10, pp. 250-253, May, 1914.

Lithologically the Alum Bluff formation is extremely variable. At the type locality the formation consists as already stated chiefly of calcareous and slightly phosphatic sands. Below the sand is found shell marl, while above is found cross-bedded sands and clays containing plant fossils. Elsewhere the formation holds clay beds, including the workable fuller's earth beds of Florida. In its eastward and southward extent the formation consists chiefly of a sandy phosphatic marl, the phosphate being found in the form of pebbles and probably also in a finely divided condition.

The phosphate pebbles in the formation vary in color from shiny, black to pure white. In size they vary from exceedingly minute pebbles not larger than sand grains to masses two or three inches in diameter. In shape they are usually more or less rounded or flattened. The small ones are as a rule nicely rounded, smooth and shiny, while the large ones are often angular or very imperfectly rounded. The pebbles, especially the larger ones, when broken are found to be by no means homogeneous in structure, but include sand grains, casts of shells and minute phosphate pebbles. In structure the large pebbles are essentially the same as the matrix, and it would seem that the pebbles took their present shape and size at the time the marl was being accumulated, and that the large ones represent mud balls made of the material that was then accumulating in the ocean.

The following analyses are of pebbles from the Alum Bluff formation. Analyses by the State Chemist of Florida.

Analysis of phosphate pebbles washed from the bed rock of the Pierce Phosphate Company, Pierce, Florida. Air dried sample.

Moisture	.97
Insoluble matter, sand etc.	10.75
Phosphoric acid, 19.41, equivalent to tri-calcium phosphate	42.39
Iron and alumina	0.19
Calcium oxide, 16.79, equivalent to calcium carbonate	38.20

Analysis of phosphate pebble washed from bed rock marl of the Phosphate Mining Company, near Mulberry, Florida. Air dried sample.

Moisture	.94
Insoluble matter, sand, etc.	6.11
Phosphoric acid, 24.88, equivalent to tri-calcium phosphate	54.34

Iron and alumina	0.27
Calcium oxide, 7.58, equivalent to calcium carbonate	17.24

Analysis of phosphate pebble washed from the Alum Bluff marl near Lulu, Florida. Air dried sample.

Moisture	1.84
Insoluble matter, sand, etc.	22.46
Phosphoric acid, 26.93, equivalent to tri-calcium phosphate	58.82
Iron and alumina	3.02
Calcium oxide, 1.85, equivalent to calcium carbonate	4.21

Analysis of phosphate pebble washed from the phosphatic marl on Black Creek, Florida. Air dried sample.

Moisture	.88
Insoluble matter, sand, etc	18.94
Phosphoric acid, 24.45, equivalent to tri-calcium phosphate	53.40
Iron and alumina	0.23
Calcium oxide, 5.07, equivalent to calcium carbonate	11.53

The matrix in which the pebble phosphate is imbedded, is prevailingly a light colored yellow or sandy phosphatic marl, varying in texture from soft and granular to hard and compact. The sand consists of clear grains of quartz. The following is an analysis of a sample of this marl:

Analysis of sample of the bed rock marl from pit No. 5 of the Phosphate Mining Company, near Mulberry, Florida. Air dried sample.

Moisture	5.03
Insoluble matter, sand, etc.	43.45
Phosphoric acid 6.77, equivalent to tri-calcium phosphate	14.79
Iron and alumina	0.25
Calcium oxide, 10.41, equivalent to calcium carbonate	23.64

PLIOCENE.

THE BONE VALLEY FORMATION

The upper Oligocene in the land pebble phosphate section of southern Florida is succeeded by the Bone Valley formation which is of late Miocene or early Pliocene age, a part or all of the Miocene being absent in this part of the State. The lower member of this formation contains the land pebble phosphate beds. That part of the formation above the phosphate bed consists chiefly of gray phosphatic sands, variable in thickness. At some localities owing to surface erosion they are almost entirely removed, although elsewhere they attain a thickness of thirty feet or more. As a rule the sands are but slightly indurated. Locally, however, they form a hard rock with innumerable small cavities which give a vesicular appearance to the mass. A sample of the rock of this kind was found to contain 15.56% phosphoric acid (equivalent to 33.97% tri-calcium phosphate).

At the surface is found as a rule incoherent pale yellow sand, which although variable has an average thickness of five to ten feet. It seems probable that these loose surface sands are merely residual having been derived by disintegration from the phosphatic and for the most part slightly indurated sands beneath.

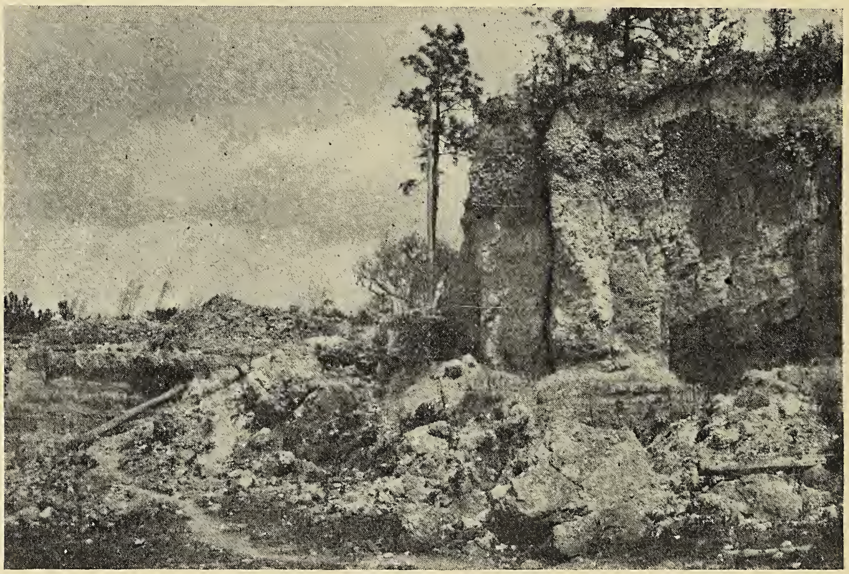


Fig. 2.—View in the Pembroke mine of the Coronet Phosphate Company, showing the gray more or less indurated phosphatic sands which lie above the workable phosphate bed. The gradation of the phosphatic sand into the loose surface sand and soil may be seen in this view.

Although variable from place to place the phosphate beds have an average thickness of from eight to twelve feet; the maximum thickness over considerable areas, is possibly from eighteen to twenty feet, although locally, owing to depressions in the bed rock the phosphate may be much thicker.

The phosphate beds are more or less definitely stratified, the bedding planes being frequently continuous for the full length of the exposures in the pit, some of which are a half mile or more in extent. Elsewhere the stratification is irregular and cross bedding is evident.

The phosphate in this formation consists of rounded, flattened or angular pieces of rock or pebble, together with fragments of bones and casts of shell. The phosphate rock presents no regularity or uniformity in size or form and from the same matrix may be washed pieces varying from 1 mm. or less to 50 mm. or more in diameter, or in weight from a few milligrams to several ounces. The larger pieces when examined under a lens are usually found to contain grains of sand, small phosphate pebbles and casts of shells imbedded in a matrix of nearly uniform texture. The small phosphate pebbles are often well rounded.

In color the phosphate rock is likewise variable. Some of the pieces are white, while others are tinged with yellow, cream colored, brown, amber colored, gray and black. A few of the pebbles, especially the smaller ones, are of uniform texture throughout. With many of the pebbles, however, the outer layers are more compact and probably more highly phosphatized than is the interior.

Analysis of phosphate pebbles washed from the phosphate bed at the mine of the Pierce Phosphate Company, Pierce, Florida. Air-dried sample.

Moisture	1.81
Insoluble matter, sand, etc.	6.62
Phosphoric acid, 30.67, equivalent to tri-calcium phosphate	66.98
Iron and alumina	1.32
Calcium oxide, 3.05, equivalent to calcium carbonate	6.94

Analysis of phosphate pebbles washed from the phosphate bed at the mine of the Prairie Pebble Phosphate Company near Mulberry, Florida. Air-dried sample.

Moisture	1.33
Insoluble matter, sand, etc.	6.87
Phosphoric acid 35.34, equivalent to tri-calcium phosphate	77.18
Iron and alumina	0.93
Calcium oxide, 1.39, equivalent to calcium carbonate	3.16

Analysis of phosphate pebbles washed from the phosphate bed at the mine of the Phosphate Mining Company, near Mulberry, Florida. Air-dried sample.

Moisture	3.22
Insoluble matter, sand, etc.	.35
Phosphoric acid 34.73, equivalent to tri-calcium phosphate	75.85
Iron and alumina	0.28
Calcium oxide, 3.73, equivalent to calcium carbonate	8.49

The matrix in which the phosphate pebbles are imbedded includes chiefly sand, clay, corals, rock fragments, flint pebbles, fossil bones, shells and petrified wood. The following analysis is of the matrix including the phosphate pebbles.

Analysis of the matrix of the land pebble phosphate. Sample from mine of the Prairie Pebble Phosphate Company near Mulberry. Air-dried sample.

Moisture	.78
Insoluble matter, sand, etc.	25.18
Phosphoric acid 26.73, equivalent to tri-calcium phosphate	58.38
Iron and alumina	7.51
Calcium oxide, 1.02, equivalent to calcium carbonate	2.32

The relation of the Bone Valley formation to the Oligocene deposits beneath is that of unconformity throughout. Of the other Pliocene formations of Florida, the Caloosahatchee and Nashua marls, it will not be necessary to speak at this time since they lie for the most part south and east of the phosphate area, and moreover have been described in the preceding reports of the Survey.

PLEISTOCENE.

The Pleistocene of southern Florida west of the Everglades is confined to deposits lying near the coast. Of these it will be necessary to consider only those in the stream valleys which hold the river pebble phosphate, the best known being the Peace Creek beds.

Before continuing the description of the formations holding the phosphate deposits, however, it may be well to give some further account of the structure and geologic history of southern Florida.

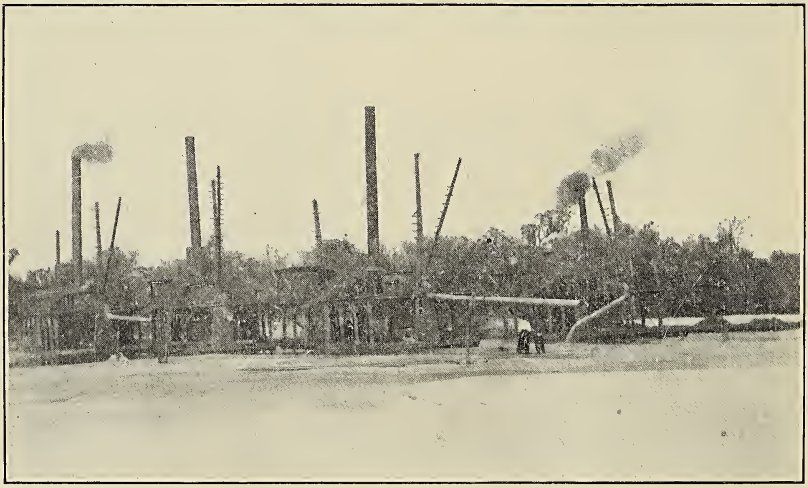


Fig. 3.—Mining river pebble phosphate on Peace Creek.

STRUCTURE OF SOUTHERN FLORIDA.

THICKNESS AND SUCCESSION OF FORMATIONS.

With regard to the thickness and succession of the formations underlying the pebble phosphate deposits in southern Florida, the best record that is at present available is that which has been obtained through the study of samples from wells drilled at and near Tiger Bay by the Palmetto Phosphate Company, at Christina by the Phosphate Mining Company, and at Fort Myers by the Ohio Well Drilling Company.

Description of samples from well No. 3 of the Palmetto Phosphate Company, Tiger Bay, Florida.

Depth of sample from the surface.

73 feet. The rock at this depth is a light colored phosphatic marl or limestone. In texture and appearance it is like the marl which lies beneath the land pebble phosphates. The phosphate is in the form of smooth, rounded black, brown, and white pebbles. While this is the prevailing material of the sample, at least one fragment consists of clear grained quartz, held together by a phosphatic or calcareous cement and resembling Alum Bluff sands. Acid test showed this piece to be but slightly if at all calcareous. There are also some fragments of dark blue hard rock which effervesce but slightly in acid. No fossils were seen in this sample.

85 feet. This is also a phosphatic marl or limestone. It is similar to the 73-foot sample except that it is lighter in color, being light gray or nearly white. The phosphatic pebbles are mostly black in color, the black pebble in the light colored marl giving a grayish cast to the rock. The hard blue rock that effervesces scarcely at all in acid is rather more abundant in this than in the preceding sample. This hard rock also contains black phosphate pebbles and it is probable that it is merely a silicified phase of the marl. Some casts of fossils but no determinable specimens. A considerable amount of clear grained siliceous sand is seen among the finer material.

150 feet. The material at this depth is also calcareous and phosphatic. The phosphate pebbles are black or brown and are smooth and rounded. The rock contains numerous small cavities giving it a porous appearance. Only one fossil is seen, this being part of a small gastropod.

160 feet. A phosphatic limestone or marl with some fossil gastropods and bivalves preserved as casts. The rock at this depth is in general similar to the 150-foot sample. The fossils seem more abundant perhaps because the sample is larger. The phosphate pebbles are black, brown, and white in color.

180 feet. Compact brown, phosphatic limestone. The phosphate pebbles are not abundant in this limestone and are in the form of small black pebbles imbedded in the rock. While the rock is prevailingly compact some porous fragments are seen. A few broken fossils preserved as casts.

190 feet. This sample includes compact phosphatic limestone with about equal admixture of pure white siliceous sand. Whether the sand is from a sand stratum or from the six-inch cavity found at this depth, or possibly accidentally mixed from the surface, is not known.

195 feet. A sandy, calcareous and phosphatic clay. In water this material falls to pieces and becomes slippery. In acid it effervesces. The sand is in the form of clear grained silica. The phosphate is mostly in the form of small black pebbles. Material is light colored when dry, although slightly bluish when wet.

200 feet. This material is similar to that at 195 feet although there is perhaps less phosphate, and the sand is perhaps smaller grained.

205 feet. A gray sandy phosphatic limestone. The calcareous material seems to predominate, although the rock is rather sandy. The sand grains are small and well rounded. The phosphate is in the form of very minute dark specks and the rock possibly also has a phosphatic cement. No fossils seen.

240 feet. A gray sandy phosphatic limestone. The calcareous material seems to predominate although the rock is rather sandy, the sand grains are small and well rounded. The phosphate is in the form of very minute dark specks and the rock possibly also has a phosphatic cement. No fossils seen in this material, except some imperfect casts in fragments of a porous limestone which may have fallen down from a higher stratum. These porous pieces occur also in the sample at 205 feet.

250 feet. Light colored sandy and phosphatic limestone. The sand grains are clear silica. The phosphate pebbles are dark colored. A few fragments of casts of fossils. This rock is not materially different from that at 205 and 240 feet except that it is lighter in color.

255 feet. Bluish gray, sandy, phosphatic limestone together with loose calcareous sand probably representing the ground-up rock. No fossils seen except echinoderm spines.

255 to 260 feet. Gray or blue calcareous sandy phosphatic clay. No fossils. This material is similar to that at 200 feet.

265 feet. Bluish gray sandy phosphatic limestone together with loose calcareous sand probably representing the ground-up rock. No fossils seen except echinoderm spines.

272 feet. Light colored sandy phosphatic limestone. This is very similar to the rock above the blue clay. A few fossils including fragments of *Pecten*. Also one flattened water-worn pebble of the same material as the rock above.

275 feet. The greater part of the material of this sample is the bluish gray sandy phosphatic limestone similar to that already described. With this is found a light colored compact limestone, very slightly phosphatic as shown by test. The sample also contains several pieces of red iron ore. Of fossils only a few fragments were seen.

320 feet. Light colored phosphatic and slightly sandy marl or limestone. The phosphate is in the form of smooth dark pebbles imbedded in the marl. The rock is fossiliferous, although the fossils are badly broken.

350 feet. Light colored phosphatic marl or limestone more or less sandy. One small fragment of chalcedony holding cast of shell. A few fossils mostly broken bivalves and gastropods. The sample includes some bluish gray sandy phosphatic limestone.

360 feet. Light colored phosphatic sandy marl, also some bluish gray sandy phosphatic marl or limestone. Some broken fossils are included.

400 feet. Light colored, finely powdered marl or limestone. Fragments of echinoderm spines are present and other small or broken fossils. A few phosphatic pebbles are seen, being black and shiny in appearance. A clear grained quartz sand occurs sparingly. This material is less phosphatic than that which lies above and resembles the Chattahoochee limestone as seen at Newland Spring near Falmouth in Suwannee County and near Bass in Columbia County. Test showed this powdered material to contain a small amount of phosphate.

410 feet. Light colored finely powdered marl or limestone. Fragments of echinoderm spines are seen, and also other small fossils including a few bryozoa. This material is similar to that at 400 feet, although there seem to be no phosphatic pebbles and little if any sand.

420 feet. Light colored, nearly white limestone not so finely powdered as the preceding two samples. Fragments of broken shells are abundant. Bryozoa are numerous. Some foraminifera are present, the most common being *Orbitoides*. This limestone is with little doubt the Ocala. Test shows it to be not phosphatic.

450 feet. The limestone at this depth is practically the same as that at 420 feet. It is light colored or nearly white, fragments of broken shell are abundant, among which *Pecten* is recognized. Small foraminifera are numerous, and there are also broken pieces of larger specimens. Bryozoa are present.

500 feet. Foraminifera abundant, chiefly *Orbitoides,* including large specimens, most of which are broken by the drill.

550 feet. Foraminifera abundant. The material is similar to that at 500 feet.

600 feet. At this depth foraminifera are abundant. The predominating form is *Nummulites. Orbitoides* present but not abundant. The sample includes also some pieces of a soft, granular white marl.

630 feet. Limestone, probably hard and compact, the sample being finely powdered by the drill. Both *Nummulites* and *Orbitoides* are present, although only the small specimens escaped being powdered by the drill. This compact limestone has a slightly brownish cast.

636 feet. Hard compact limestone with brownish cast powdered exceedingly fine by the drill. Few fossils escaped being powdered up, although some foraminifera and bryozoa are present.

650 feet. This sample shows a mixture of finely powdered material with brownish cast together with coarser material from a softer rock. With the coarser material is included some small pieces of bluish colored chert. Foraminifera are present.

665 feet. A limestone breaking into coarse fragments. The predominating fossil is a small flat echinoderm, the internal cavity of which is in most cases filled with calcite crystals. Foraminifera are also present, although not numerous.

670 feet. A compact limestone with slightly brownish cast. The same small flat echinoderm is present, although broken up by the drill, and is not abundant. Foraminifera are present, although not abundant.

680 feet. A brown limestone rather hard but not very compact. Few if any fossils are preserved. It is probable that the minute fossils in the rock have dissolved out, and the cavity partially refilled by calcite crystals. This gives the rock a porous and partially crystallized appearance and causes it to break into medium coarse fragments by the drill.

690 feet. The material is chiefly light brown or grayish brown porous limestone partially crystallized, the fossils having been destroyed. With this is included light colored rock.

710 feet. This sample consists chiefly of soft white limestone in which is included a few foraminifera. A limited amount of the harder brownish rock from the stratum above is present.

720 feet. A light colored, rather hard, although porous, limestone which seems to be made up of a mass of broken shells and other fragments of fossils. One small flat echinoderm present, although broken.

740 feet. White granular limestone. Fossils not numerous, although a few foraminifera are seen; also broken pieces of a small flat echinoderm.

760 feet. Grayish brown limestone, rather hard and partly crystallized. A few fossils, including a small gastropod.

770 feet. Grayish brown limestone, rather hard and partly crystallized. Few, if any, fossils.

790 feet. The greater part of the material of this sample is brown or grayish brown powdered up by the drill medium fine. With this are several large pieces of ground rock which consists almost entirely of a mass of small calcite crystals. The sample contains also some light colored material including a few foraminifera.

800 feet. The material of this sample is similar to that of the last. The large fragments consist chiefly of a mass of small calcite crystals, the mass being brown in color.

814 feet. The rock at this depth is not unlike that at 800 feet, although it is darker in color, being very dark brown, somewhat compact and partly crystallized.

820 feet. A light colored limestone which powders up medium fine in drilling. Foraminifera present.

830 feet. A light colored limestone which powders up medium fine in drilling. Foraminifera present, although not abundant.

838 feet. The greater part of this sample is white and rather soft limestone;

there are also some pieces of a white limestone consisting chiefly of broken fragments. With this are some dark colored pieces which probably scaled off of the side of the cavity. A small flat echinoderm is present.

Description of samples from well No. 3 of the Palmetto Phosphate Company, near pit No. 1 about 2¾ miles northwest of Tiger Bay.
Depth of sample from the surface.

8 to 16 feet. The material from this depth represents the Bone Valley formation.

30 to 40 feet. Yellow sandy and clayey phosphatic marl. The phosphate is chiefly in the form of smooth rounded light or dark pebbles. Smooth siliceous pebbles are also present. This material represents the "bed rock," which is the Alum Bluff formation.

40 to 50 feet. Light colored marl with some bluish calcareous clays and pebble phosphate.

50 to 60 feet. Gray phosphatic sandy marl.

60 to 90 feet. Light colored limestone, including some phosphate pebbles and broken pieces of chert.

90 to 105 feet. Light colored limestone, light and dark phosphate pebbles and broken pieces of chert.

115 to 125 feet. Phophate pebbles and pieces of broken chert, and light colered limestone.

141 feet. A rather hard light brown limestone, including phosphate pebbles and some light colored limestone and broken pieces of chert.

143 feet. Porous limestone and marl with an abundance of black phosphate pebbles.

160 feet. Light colored porous limestone or marl with black phosphate pebbles.

170 to 190 feet. Rather hard brownish limestone, with some phosphate pebbles and occasional casts of shells.

200 to 210 feet. Rather hard, light colored or gray sandy phosphatic limestone. The phosphate is chiefly in the form of minute black pebbles.

218 to 223 feet. Slightly greenish sandy phosphatic and calcareous clays. This clay is much like a part of the sample obtained from well No. 3 at 255 to 260 feet.

223 to 226 feet. Light colored or gray phosphatic limestone or marl very similar to the rock at 210 feet.

226 to 252 feet. Slight greenish sandy phosphatic clay, much like that at 218 to 223 feet.

253 to 260 feet. The material at this depth consists chiefly of a greenish, very sandy phosphatic marl. The fossils observed include several sharks' teeth and casts of shells. Also teeth of the ray. In addition to the greenish marl, is found some light colored limestone or marl containing casts of shells.

275 to 290 feet. This sample consists in part of greenish sandy phosphatic marl similar to that at 253 and 260 feet, containing teeth of sharks and rays. The sample also includes a light colored nearly white limestone, containing small shells, bryozoa and spines of echinoderms.

300 to 320 feet. Light colored or white granular limestone including broken shells, spines of echinoderms, bryozoa and other fossils.

330 feet. Hard brownish limestone powdered fine in drilling.

337 and 350 feet. Light colored or white granular porous limestone, shells preserved as broken fragments.

360 to 530 feet. Ocala limestone consisting of a mass of broken shells, among which *Orbitoides* predominates.

540 to 560 feet. Ocala limestone in which *Nummulites* as well as *Orbitoides* are abundant.

570 and 580 feet. Echinoderm horizon, the samples consisting almost wholly of a small echinoderm.

590 feet. Rather hard limestone with brownish cast. *Nummulites* and *Orbitoides* present although not abundant.

600 feet. This sample, like those at 570 and 580 feet, consists of a mass of small echinoderms.

620 to 660 feet. The samples throughout this interval consist chiefly of a hard limestone of brownish color which is powdered fine by the drill.

670 feet. This sample consists largely of very small brownish calcite crystals. After the well had been completed and allowed to stand for some time, 8 to 10 bushels of this material was pumped from the well, having been carried into the well from the cavity in the rock.

680 to 740 feet. The samples throughout this interval are from a hard limestone, brownish in color, which as a rule is powdered rather fine by the drill.

750 and 770 feet. Small calcite crystals which were pumped from cavities.

Description of samples from the well of the Phosphate Mining Company. Well located at Christina, Florida. Depth of well 800 feet.
Depth of sample from the surface.

100 feet. The rock at this depth consists of sand with slightly greenish tinge together with fragments of a light colored marl containing small black phosphate pebbles.

120 to 300 feet. Samples at twenty-foot intervals. The rock throughout this depth is a light colored limestone having an appearance of a mass of broken fragments.

320 to 460 feet, samples at twenty-foot intervals. The rock throughout this interval is a light colored limestone containing an abundance of foraminifera.

480 and 520 feet. Light colored granular limestone.

540 feet. Light colored limestone with small, flat echinoderms.

560 to 680 feet, samples at twenty-foot intervals. Light to brownish colored limestones.

800 feet. Light colored granular limestone.

Description of samples from the city well, Ft. Myers, Florida, drilled 1914, driller Ohio Well Drilling Company, Jacksonville, Florida. Size 10 and 8 inches; casing 10-inch, 14 feet; 8-inch, 203 feet; principal water supply 875 feet; flowing yields 650 gallons per minute, depth 950 feet; in charge of drilling, G. P. Peppard. Depth of sample from the surface.

200 feet. Light colored limestone with fragments of fossils, also some sand and dark, shiny phosphate pebble. Fossils include bryozoa, broken shell fragments, etc.

210 feet. Much the same rock. Shark's tooth, some phosphate pebble, broken shells, some echinoderm spines and many bryozoa.

220 feet. Similar light colored limestone. Some fine black phosphate pebble imbedded in the rock.

230 feet. Similar light colored limestone.

280 feet. Similar light limestone consisting of broken shell fragments together with fragments of rock containing minute black phosphate pebble.

300 feet. Similar light colored limestone consisting of broken fragments of different shells together with some pieces of hard, dark colored rock.

320 feet. Similar light colored limestone consisting of shell fragments.
360 feet. A similar light colored limestone containing also small shiny black phosphate pebbles.

340 feet. Similar light colored limestone with an abundance of small shiny black phosphate pebbles.

380 feet. Similar light colored limestone consisting of a mass of broken shell fragments, rather more finely broken up than the preceding. Phosphate pebbles somewhat less abundant than in last sample.

400 feet. Similar light colored limestone consisting of a mass of shell fragments broken up finely.

420 feet. Similar light colored limestone, some phosphate pebble as in preceding.

440 feet. Similar light colored limestone, including phosphate pebble, also one small oyster shell.

460 feet. Similar light colored limestone, although not so finely broken up and including pieces of rock with the small phosphate pebbles imbedded.

480 feet. Buff calcareous clay, some phosphate pebble and some shell fragments.

500 feet. Light colored limestone consisting of shell fragments with an abundance of black phosphate pebble and with small fragments of the sandy marl with slightly green shade of color.

520 feet. A somewhat harder limestone, containing, however, phosphate pebble.

540 feet. Limestone similar to that at 520. This limestone is not so light in color and does not contain so many shell fragments as the limestone above 320 feet.

600 feet. Very fine, siliceous and calcareous sand containing minute black phosphate pebble.

640 feet. Same as 600.

680 feet. Similar finely powdered material containing, however, less quartz sand.

720 feet. Limestone with slightly brownish color and finely powdered by the drill.

760 feet. Finely powdered calcareous material similar to that at 600 feet.

800 feet. Light colored limestone consisting of a mass of broken fossils.

840 feet. Same as at 800 feet.

880 feet. Same as at 800 feet.

900 feet. Finely powdered rock including fine quartz sand much like that at 600 feet.

950 feet. Limestone consisting of a mass of broken fossils.

The thickness and succession of formations underlying the pebble phosphate beds as indicated by these records is as follows:

1. Bone Valley formation. The thickness of this formation is not shown by the samples, but the formation is always comparatively thin and when mined is worked to the bottom where it rests upon the phosphatic marl known as the "bed rock."

2. Beneath the land pebble phosphate beginning with the "bed rock" as the term is used in the mining operations, is found a succession of phosphatic marls extending at Tiger Bay to a depth of about 360 feet. At Christina, about 16 miles north of Tiger Bay the formation is not more than 100 feet thick, while at Fort Myers about 70 miles south of Tiger Bay it is at least 600 feet thick. The material throughout this whole thickness, while by no means uniform, apparently represents a single geologic formation which is locally variable, the phosphate pebbles which occur throughout the whole thickness are black, brown or white in color and are rounded, smooth and shiny. The pebble is imbedded in a marl, the prevailing color of which is light buff or grayish. The marl is throughout more or less sandy, so much that in some of the samples it becomes almost a calcareous sandstone. Locally the material of this marl has be-

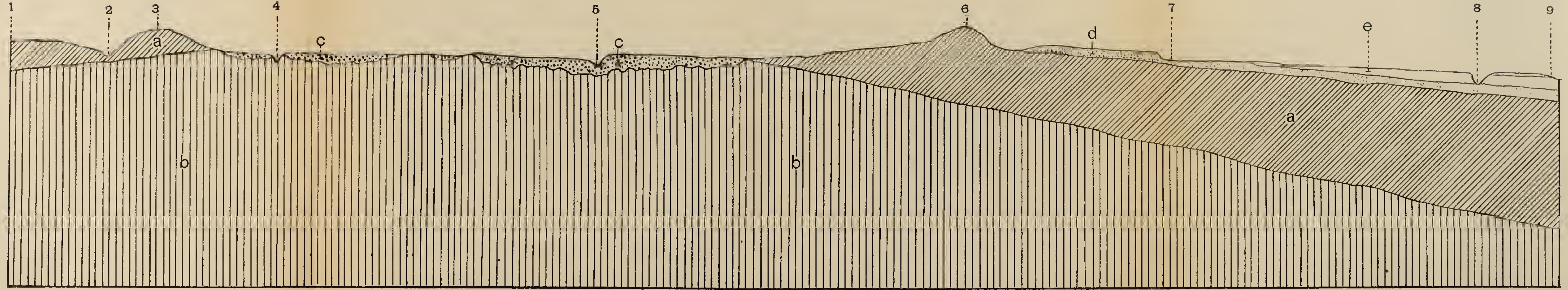
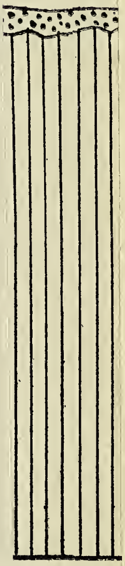


Fig. 4.—A diagrammatic sketch drawn to illustrate the geologic structure of Florida as found on a line from north to south passing through the hard rock and pebble fields, showing the relation of the phosphate deposits to the underlying formations. Horizontal scale, 1 inch=16 miles; vertical scale, 1 inch=400 feet. (1) Georgia-Florida State line. (2) Suwannee River. (3) Lake City. (4) Santa Fe River. (5) Withlacoochee River. (6) Lakeland. (7) Arcadia. (8) Caloosahatchee River. (9) Gulf Coast. (a) Upper Oligocene phosphatic marls. (b) The Ocala limestone. (c) The hard rock phosphate deposits. (d) The Bone Valley formation which holds the land pebble phosphate deposits. (c) Pliocene and Pleistocene deposits.



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come compact and close grained, probably in the form of small boulders which are broken up in drilling. Boulders of this type may be either calcareous or flinty. While fossils are not abundant it is probable that this phosphatic marl is of Upper Oligocene age. The marl is with little doubt the parent formation from which by reworking and concentration the pebble phosphate conglomerate of the Bone Valley formation was formed.

3. Beneath the phosphatic marl is found limestone in which all the wells terminate. At Tiger Bay the first 50 feet of this limestone, 360 to 410 feet from the surface, consists largely of a mass of small pieces having the appearance of broken fragments of fossils. Below 410 feet the prevailing phase is a light colored limestone, often granular in appearance, containing many foraminifera. Occasional strata are found which are hard and compact and usually of a brownish color, the material being finely powdered by the drill. Locally also flint masses occur which represent silicified limestone and may or may not be encountered in any particular well. Locally also the limestone is partially crystallized, this phase being due to solution and redeposition by underground water. At Christina the limestone beneath the marl is reached at a depth of about 120 feet, and foraminifera become abundant at about 320 feet. At Fort Myers the non-phosphatic limestones are reached at about 700 feet. The rock in which foraminifera are abundant is believed to represent the Ocala limestone and it may be that all of the non-phosphatic limestones beneath the phosphatic marl are of that formation.

The generalized sketch (fig. 4) has been drawn to illustrate the geologic structure as found on a line through the State from north to south passing through the pebble and hard rock phosphate section. The relation of the phosphate deposits to the underlying formations is well shown by this sketch. The foundation rock is the Ocala limestone which comes to the surface over a limited area in the central peninsula section. The hard rock phosphate deposit rests directly upon this limestone. To the south and also to the north the limestone dips below the surface and disappears beneath the later formations. The upper Oligocene formations lie upon the Ocala limestone in extreme northern and southern Florida. The Bone Valley formation, including the land pebble phosphate, in turn rests upon these upper Oligocene deposits. In extreme southern Florida Pliocene and Pleistocene marls and sands form the surface materials.

GEOLOGIC HISTORY OF SOUTHERN FLORIDA.

If the areal and structural geology has been correctly described, the geologic history of southern Florida may be readily interpreted, so far at least as it affects the problem of the formation of the phosphate deposits. Several periods of deposition are recognized separated by more or less well marked intervals of emergence and erosion.

PERIOD OF DEPOSITION OF LATE EOCENE SEDIMENTS

The Ocala limestone which underlies the Florida peninsula and is probably of Eocene age is of marine origin having accumulated in sea water of medium depth, and under conditions that were uniform over large areas, and for a long period of time.*

POST-EOCENE PERIOD OF EMERGENCE AND EROSION

The conditions which permitted the accumulation of the Ocala formation continued probably into the Oligocene, and was then followed by a period of emergence during which the Florida plateau was lifted above sea level, becoming dry land. It is difficult to determine the extent of this uplift. That dry land areas existed, however, is shown by the fact that the top surface of the Ocala limestone is irregular having been worn uneven by erosion. Moreover, the earliest of the upper Oligocene deposits that accumulated in the vicinity of Tampa contain a very conspicuous element of land and fresh water fauna, particularly mollusks,† thus showing that the shore line at that time was at no great distance from that locality.

PERIOD OF DEPOSITION OF UPPER OLIGOCENE SEDIMENTS

A widespread submergence permitted the extension of the sea over large areas during upper Oligocene that for a time had been dry land. The deposits that accumulated in Florida at the time of this submergence include the Chattahoochee, Tampa and Alum Bluff formations, the characteristics and extent of which have already been described. The distribution of these formations is such as to leave little doubt, but that at the time of maximum depression the whole of the peninsula was submerged.

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*Vaughan, T. Wayland, A Contribution to the Geologic History of the Floridian Plateau, Carnegie Institution of Washington, Publication No. 133, pp. 99-185, 1910.

†Dall, W. H., Contribution to the Tartiary fauna of Florida. Wag. Free Inst. Sci. Trans. Vol. iii, pp. 3-14, 1890; U. S. Nat. Mus. Bull. 90, pp. 18-19, 1915.

POST-OLIGOCENE PERIOD OF EMERGENCE AND EROSION

The upper Oligocene time was followed by a period of emergence which evidently was very extensive bringing much of the present peninsula above water level. Evidence of this emergence is found in the fact that the top surface of the upper Oligocene deposit is irregular indicating surface erosion. Moreover, the succeeding formations without exception where the contact is observed, rest unconformably upon the upper Oligocene. A partial re-submergence of Florida occurred during Miocene time as is shown by the fact that marine Miocene formations are found over quite extensive areas in western Florida, being exposed along the Choctawhatchee, Apalachicola and Ocklocknee rivers. Miocene deposits are also found along the Atlantic slope at Jacksonville in Duval County and at Rock Springs in Orange County, as well as on Black Creek in Clay County. As already noted, however, the Miocene formations, unless the Bone Valley formation itself is Miocene, are not found in the land pebble phosphate section of the State, from which it is inferred that this section was dry land during most, if not all of the Miocene period.

PERIOD OF DEPOSITION OF PLIOCENE SEDIMENTS

It was not until near the close of the Miocene or perhaps early in the Pliocene that the area in southern Florida in which is found the pebble phosphate deposits was again submerged. The marine formations that accumulated in Florida during the Pliocene include in addition to the Bone Valley formation, which contains the land pebble phosphates, the Caloosahatchee and Nashua marls. That the submergence at this time was extensive is shown by the wide distribution of these formations in southern and eastern Florida.

The Pliocene period was closed in Florida by an uplift, which if of no great extent vertically, was at least sufficient to add materially to the land area of the peninsula.

CHANGES IN LEVEL DURING PLEISTOCENE TIME

With the events of Pleistocene time, we are not so directly concerned in this paper. It is apparent, however, that appreciable changes in level occurred during the Pleistocene, to some of which it will be necessary to refer. Early Pleistocene deposits are found fringing the Gulf shore of southern Florida and the Atlantic border of eastern Florida. Marine Pleistocene shell beds are found on Six-Mile Creek in Hillsboro County; near Bradentown, and at North Creek in Manatee County; on the Caloosahatchee River and generally over the Everglades, and thence north along the Atlantic Coast. Following the deposition of these early Pleistocene shell marls, the peninsula was lifted probably by successive minor oscillations to a level somewhat above its present elevation.

Finally, a slight depression probably during the late Pleistocene, brought the peninsula to its present level. Undoubted evidence of this late Pleistocene depression is found in the fact, long ago noted by Shaler,* that the important harbors of Florida, among which may be mentioned Charlotte Harbor and Tampa Bay, represent flooded river valleys. Additional confirmatory evidence is derived from many sources. Captain O. N. Bie of the United States Engineering Corps reports that while dredging the channel to Tampa there was encountered about seven miles below Tampa at a depth of 20 feet a mass of cypress limbs and branches, indicating probably the location of a Pleistocene cypress swamp which existed at a time when the land area stood not less than 25 or 30 feet higher than at present. On the Florida Keys Mr. W. J. Krome, Construction Engineer of the Florida East Coast Extension, reports the existence of swamp and peat deposits at places along the Keys at a depth beneath the marls of as much as 20 feet.

SUMMARY OF THE GEOLOGIC HISTORY

By way of summary of that part of the geologic history of southern Florida which specially concerns the origin of the pebble phosphates, it may be well to repeat, that during the late Oligocene time there accumulated over a part of Florida the great phosphatic marl known to the miners of pebble phosphate as the "bed rock." The phosphate in this marl existed in the form of pebbles of various sizes, shapes, and colors, and probably also as soft, or finely divided phosphate. Following the deposition of this marl a very large part of Florida became dry land. The marls were thus subjected to surface erosion, by which the top surface came to present the irregularities characteristic of and common to exposed land surfaces. This period of emergence and erosion continued apparently during the greater part, if not all of the Miocene period. Near the close of the Miocene or early in the Pliocene came a period of submergence permitting the sea to cover large areas of Florida that had previously been dry land. In connection with and following this Pliocene submergence was accumulated the Bone Valley formation, the first or lowest member of which holds the land pebble phosphates. With these facts regarding the geologic history of southern Florida in mind it becomes possible to understand and account for the pebble phosphate deposits, and to explain many of the peculiarities of the formation.

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*Shaler, N. S., The Geological History of Harbors. U. S. Geol. Sur. 13th Ann. Rept., pt. 2, pp. 190-192, 1893.

THE LAND PEBBLE PHOSPHATE DEPOSITS

With regard to the genesis of the land pebble phosphate deposits Eldridge in 1893 wrote as follows:*

> The resemblances in texture, color, fossil casts, and general appearance which the pebbles of this deposit occasionally bear to the hard-rock type are in a measure suggestive of their derivation from a limestone of pre-Pliocene times possibly older Miocene. On the other hand the prevailing white color, the often earthy appearance of the fresh surfaces, the lower percentage in phosphate of lime, the softness and the condition of preservation of included fossils suggest their origin from a marl or at least a very earthy friable limestone. In either case they may be the rolled fragments of pre-existing beds, a possibility enhanced by the character of their matrix and by the occasional presence of well-rounded, white quartz pebbles.

Shaler was of the opinion that the land pebble phosphates of Florida should be placed in the category of Residual Ablation Deposits. He says, as quoted by Eldridge (l. c.):

> In the case of the pebble phosphates it is evident that the fragments have been to a certain extent swept from the uplands into the valleys. Thus on the low divides between the Alafia river district and the neighboring portions of Florida, the phosphatic pebbles may form but a thin layer or be altogether wanting, while in the valleys the accumulations of pebbly material may have a thickness of 30 feet or more. This segregative process has probably in part been accomplished by the work of the streams themselves, but it is in my opinion mainly due to the action of the sea during the time or times when this part of the peninsula has sunk beneath and risen above the ocean level. The action of the sea in this concentrative work appears to be indicated by the frequent occur-

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*A Preliminary Sketch of the Phosphates of Florida, by George H. Eldridge, Am. Inst. Min. Eng. Trans. xxi, pp. 196-231, 1893.

rence of shark's teeth and other remains of marine forms in a state of preservation which seems to me to clearly indicate that they were formed since the phosphatic pebbles took their shape. They appear indeed to be mere accidental and exceedingly modern elements of the deposit. They have evidently experienced no such attrition as has affected the pebbles themselves.

Dr. W. H. Dall regarded these deposits as of marine origin and of Pliocene age.* Messrs. Matson and Clapp, however, while recognizing the possible estuarine origin of a part of the beds, were inclined to regard the Bone Valley formation as chiefly fluviatile.†

Aside from the papers referred to above few serious attempts have been made to account for the origin of the land pebble phosphates. This is in marked contrast to the literature on the hard rock phosphates, for the origin of which a multiplicity of conflicting and often fantastic theories were offered during the early days of mining. With regard to the fluviatile origin of the beds, while the deposits were clearly accumulated in shallow water, it has seemed to the writer that the characteristics of the formation as given in the following pages indicate estuarine or shallow water marine deposits.

THE LAND PEBBLE PHOSPHATE BED A PEBBLE CONGLOMERATE ACCUMULATED UNDER MARINE OR ESTUARINE CONDITIONS.

When the sea advances across an area that previously had been dry land the first deposits accumulated are of local origin, being derived from the residual materials of the land surface, together with inclusions, fragments, and pieces broken or washed from the rock beneath. The material thus accumulated is usually coarse in texture, and in that case forms a conglomerate. If subsidence continues the conglomerate layer is followed by sediments that, having been transported a greater distance, and lodged in deeper waters, are finer, more uniform in texture, and more thoroughly assorted, than those first deposited. The stratum of coarse material at the base of a formation accumulated under these conditions is known as a basal conglomerate.

If the geologic history of southern Florida has been correctly interpreted, the sea, probably in early Pliocene time, advanced across the upper Oligocene phosphatic marl, and in doing so accumulated first of all a conglomerate layer, the materials of which, derived chiefly from the marl beneath consisted of phosphate pebble, pieces of the marl, casts of invertebrates, sand, clay, worn bones and teeth. This conglomerate, which is the land pebble phosphate bed, makes up the basal member of the Bone Valley formation. That part of the formation above the conglomerate includes the sands of the overburden. These as previously noted are as a rule phosphatic, although the phosphate is either in a finely divided form or is the cementing material in the sand, little or no phosphate pebble or other coarse material being included in this part of the formation. The change from the conglomerate to the sands is rather abrupt but is not marked by evidence of a time break.

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*Neocene of North America. U. S. Geol. Surv. Bull. 84, pp. 141-142, 1892.

†Fla. Geol. Surv. Second Annual Report, pp. 138-141, 1909.

It is usually found that the coarse material of a conglomerate, grades to finer material above. This is true of the pebble phosphate conglomerate which as already stated grades into the sands above. Within the bed itself, however, it is usually found that the coarsest part of the conglomerate is that near the top. The assorting of the materials near the base is also frequently less complete than near the top of the bed. This seemingly exceptional feature finds its explanation without doubt, in the conditions under which the beds accumulated.

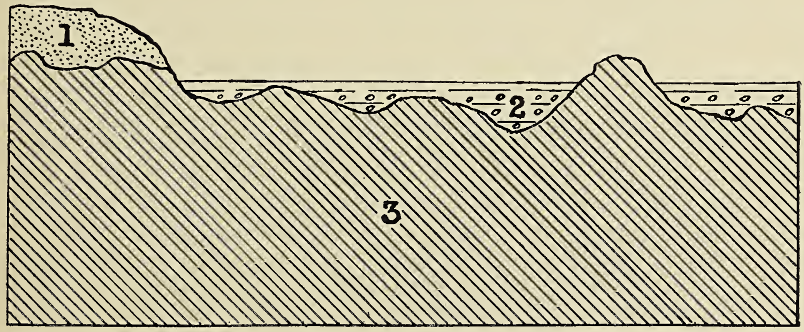

Fig. 5.—The accompanying sketch has been prepared to illustrate conditions that may have and probably did exist in this region at the time the phosphate bed was being formed. The sketch is drawn to represent a stage in the advance of a sea across a land surface, the country rock of which, a marl, presents the numerous minor irregularities characteristic of a marl or limestone country which for a time has been subjected to sub-areal erosion. The land area, not yet invaded by the sea is shown at (1); the phosphate bed that is being accumulated, shown at (2); the bed rock marl, some parts of which still project above sea level, shown by (3). That part of the land area not yet reached by the sea retains its usual covering of soil and residual material. From that part which has been invaded by the sea, however, the soil and loose materials have been shifted about, washed and more or less perfectly sorted. The organic matter of the soil has largely been removed, while the clays, sands and coarse fragments are dropped into the depressions.

A conglomerate partakes of the characteristics of the rock from which it is derived. In regions where the country rock is resistant, and especially where it is shattered by the action of frost, the residual material on the hillsides and in the stream beds is likely to contain a large proportion of coarse rock fragments. The rock from which the conglomerate of the pebble phosphate beds was derived, however, is for the most part a rather soft marl with a varying amount of sand, clay and phosphate pebble. The residual material that accumulates when a rock of this character is submitted to a sub-areal erosion consists, as may be seen in sections where this formation is now the country rock, chiefly of sand and clay, there being only a limited amount of phosphate pebble in the sub-soil. Under these conditions it is not surprising to find that the materials first accumulated in the depressions contain frequently a considerable proportion of sand and clay, while that which follows may include a larger amount of phosphate pebble and rock fragments washed or broken by the waves or streams from the bed rock. However, as each depression is differently located with regard to the sweep of waves and the force of the currents, endless variations in the deposits accumulated must be expected. When the sea but partly covers the land and is shallow, obviously the force of the waves is slight. If depression continues until a larger part of the land is submerged, the waves gain a greater sweep. With progressing submergence, there comes a point of maximum effectiveness of wave action in washing and moving materials. Finally, however, the shore line is removed to such a distance that the phosphate pebble are no longer carried in quantities sufficient to make up workable beds. In other words the phosphate beds then give place to the phosphatic sands of the overburden.

Moreover, it is quite possible that the submergence of the land area was attended by minor oscillations in level. It is not improbable for instance, that following partial submergence and the accumulation of deposits near the shore line, the land area may have been slightly elevated. If so, the shore line was changed, and the streams of the adjacent land area rejuvenated. The phosphate deposits that had accumulated near the former shore line were then reworked, the finer materials removed, and the coarse rock reaccumulated in shallow water near the shore, the deposits resulting from this second concentration being more thoroughly washed and richer in pebble phosphate than were the beds first deposited. It seems quite possible that to some such slight oscillations in level accompanied by the reworking of the shore deposits may be due the accumulation of the conglomerate to a workable depth over the limited area in which the bed is minable.

That such minor oscillations occurred, is not only in the nature of the case probable, but is possibly indicated by an unconformity found in the phosphate bed, an account of which is given in the paragraph which follows.

STRUCTURAL FEATURES AND LOCAL DETAILS IN THE PHOSPHATE BED, THE OVERBURDEN AND THE BED ROCK.

If the view as to the origin of the phosphate deposits here presented is correct it should be possible to apply the principles involved in the explanation of some of the many irregularities in the phosphate beds, and in doing so to further test the validity of the theory itself.

UNCONFORMITY WITHIN THE PHOSPHATE BED.

The northernmost plant in the land pebble section at the present time is that of the Coronet Phosphate Company located in Hillsboro County three miles southeast of Plant City. The following sections were observed in pits Nos. 1 and 2 of this plant.

Section in pit No. 1, Coronet Phosphate Company.

1.	Pale yellow incoherent sand	4 feet.
2.	Gray indurated sand	4 feet.
3	Conglomerate of phosphate pebble, bone fragments, water worn flints and pebbles	1 to 1½ feet.
4.	Buff yellow and olive green clay with phosphate pebble	2 to 5 feet.
5.	Yellow clay and marl, "bed rock" at bottom of pit.	

Section in pit No. 2, Coronet Phosphate Company.

1.	Incoherent sand	6 feet.
2.	Indurated sands	2 feet.
3.	Conglomerate of phosphate pebble, bone fragments, water worn flints and coral	1¼ feet.
4	Buff yellow and olive green clay matrix in which phosphate pebble is imbedded	5 feet.

The superficial pale yellow sand is of medium fine texture and is non-fossiliferous. The indurated gray sand is also non-fossiliferous in the upper part. Towards the base, however, this sand grades into the conglomerate previously mentioned, the lower one to one and one-half feet being a very rich phosphate conglomerate. (No. 3 of the sections).

Evidence of an unconformity is seen in these pits between Nos. 3 and 4 of the sections. The material above the break is a coarse conglomerate consisting of phosphate pebble, water-worn flint pebble, bone fragments and worn corals. Immediately on the contact line is found a considerable amount of worn coral, some pieces of which were estimated to weigh as much as eight or ten pounds. At no other place in the phosphate beds are worn corals so numerous or so large as at this locality.

The phosphate matrix of No. 4 beneath this break contains much clay and is chiefly of a bluish color which upon exposure oxidizes to a light buff yellow. Occasional bones and flint pebbles are found also in this part of the formation. The water worn corals, however, were not observed below the unconformity. That part of the phosphate matrix below the break in deposition contains also much clay and many rounded pieces of soft phosphate while that above the unconformity contains hard pebble rock only.

This unconformity may be purely local and due merely to the action of tides or of streams in the shallow waters which after washing out a part of the phosphate bed, reaccumulated coarser material in the depression. It seems probable, however, that the unconformity, together with the observed fact that coarse conglomerate

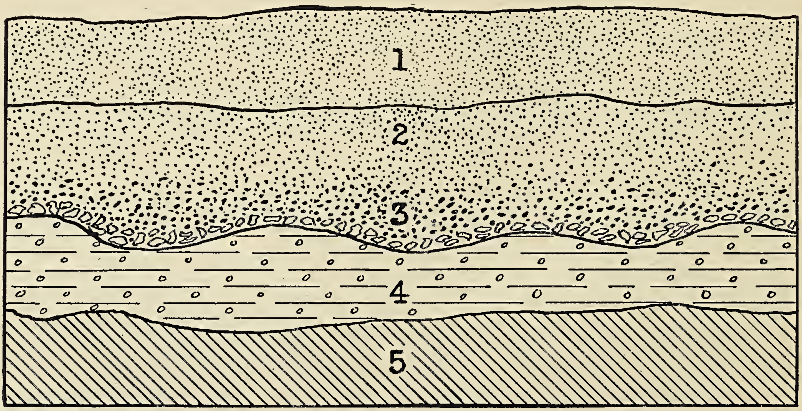

Fig 6.—Section in pit No. 1 of the Coronet Phosphate Company showing unconformity in the phosphate bed. (1) Soil and incoherent surface sand. (2) Somewhat indurated phosphatic gray sands, grading below into (3) a coarse conglomerate of phosphate pebble, worn bones, flint pebbles and silicified corals. (4) Phosphate bed containing sand, clay and phosphate pebble. (5) Bed rock marl. An unconformity is found in this section within the phosphate bed between (3) and (4), as well as at the base of the phosphate bed between (4) and (5).

lies near the top of the phosphate beds throughout the whole field, indicates a change of conditions during the time of the deposition of the phosphate beds, a slight uplift having brought about a second concentration resulting in deposits of greater thickness and richer in the percentage of pebble phosphate to the matrix than would otherwise would have accumulated over this area.

In pit No. 3 of the Prairie Pebble Phosphate Company near Mulberry the following section was observed:

1.	Incoherent sand	2 to 4 feet
2.	Indurated gray sand grading below into phosphate matrix	12 to 16 feet
3.	Workable phosphate stratum	10 to 12 feet
4.	Yellow clay marl, "bed rock" (exposed)	5 feet

The following section was observed in the pit of the Medulla Phosphate Company at Christina:

1.	Incoherent pale yellow sand and soil	2 to 5 feet
2.	Gray sand, iron stained near surface	8 feet
3.	Phosphate bearing matrix	12 to 20 feet
4.	Yellow clayey marl, "bed rock" (exposed)	4 feet

The gray sands of the overburden pass gradually into the workable phosphate bed, the upper one or two feet of which is a coarse pebble conglomerate, while that beneath contains considerable clay. The stratification lines in this pit are well marked.

IRREGULARITIES IN THE TOP SURFACE OF THE BED ROCK.

That the top surface of the bed rock is extremely irregular is a fact observed in practically all pits that have been worked, the rock presenting in fact all of the irregularities of an original land surface. This is to be expected since it is believed that the bed rock marl was subjected to erosion for a time previous to the deposition of the phosphate.

ABSENCE OF FORMATIONS OF THE MIOCENE PERIOD.

The bed rock marl is believed as has already been noted to represent deposits accumulated during the upper Oligocene time. The formation holding the land pebble phosphates on the other hand was formed as shown by the fossils which it contained either very late in the Miocene period or more probably early in the Pliocene. There is thus an almost if not complete absence of Miocene formations.

This fact is in accordance with the belief that this area was dry land during the greater part or all of the Miocene period.

LACK OF CONTINUITY OF THE PHOSPHATE BEDS.

From the prospecting records it seems probable that the conglomerate representing the phosphate bed is not continuous over the whole area. This is doubtless true and is certainly to be expected. The old land surface represented by the bed rock being irregular, it is apparent that when submerged the accumulation of the phosphate conglomerate would take place in the original valleys and depressions while the higher lands were yet submerged. The materials of the phosphate stratum are derived not from the marl immediately beneath, since that particular spot was quickly covered by the accumulation of debris, but rather from nearby marls that were as yet exposed to the force of the waves or were subjected to the action of stream currents. It is to be expected, therefore, that there are spots and doubtless considerable areas over which a pebble conglomerate of sufficient thickness to be workable did not accumulate.

VARIATIONS IN THE VERTICAL SECTION.

The phosphate conglomerate is itself by no means uniform in vertical section. The variations, however, are such as are of common occurrence in shallow water deposits. If, as is here assumed, the phosphate beds were accumulated at the time of the advance of the sea across the land surface, it is apparent that the conditions of deposition including depth of the water, force of the waves, and proximity to land must have been constantly changing, thus accounting for variations in the vertical section.

VARIATION IN THE BED WHEN TRACED LATERALLY.

If the lack of continuity of the beds, as well as their variation in vertical section, has been accounted for, little in addition need be said in regard to their variation when followed laterally, since such variations follow as a matter of course.

VARIATION IN PERCENTAGE OF THE PHOSPHATE PEBBLE TO MATRIX.

Under the theory here proposed it requires no special explanation to appreciate reasons for extreme variation in the percentage of phosphate pebble in the matrix. The fact that the materials of the beds have been subjected to the sorting power of water is of itself sufficient to account for such variations as occur.

VARIATION IN THICKNESS OF THE PEBBLE CONGLOMERATE.

The thickness of the pebble conglomerate constantly varies from place to place. This variation of thickness is due first of all to the irregularities of the bed rock. The top surface of the pebble phosphate stratum, where it grades into the overlying sands is as would naturally be expected much more nearly uniform than is the bottom of the stratum which necessarily conforms to the irregularities of the bed rock.

COLOR OF THE PEBBLE ROCK.

The pebble phosphate in the "bed rock" marl is black, amber, brown, gray or white, while the rock itself is prevailingly yellow. Accordingly the pebble conglomerate derived from the "bed rock" presents a similar range of variation in color.

VARIATION IN THE GRADE OF ROCK.

Of the many variations in the phosphate beds none is more perplexing nor of more direct concern to the phosphate operators than that of variation in the grade of rock. The variation in grade is doubtless influenced by many factors some of which as least may be accounted for. First of all it must be remembered that deposits that have accumulated through the agency of water are necessarily more or less assorted, and this is true whether the material is accumulated by surface streams or by wave action, or by both agencies combined. This partial sorting of materials while the pebble phosphate stratum is being accumulated would almost necessarily result in variation from place to place in the grade of the rock.

There is moreover another factor involved in this problem that as yet has not been specially mentioned, but which affects the grade of rock and also helps to account for some of the other variations in the beds. From the generalized geologic section given on page 53 it will be seen that the Bone Valley formation cuts across the eroded bed rock. From this it appears that the pebble phosphates are derived not from any particular stratum in the bed rock but from many different strata. It is not to be expected that the pebble from different strata in the bed rock are of the same grade. It thus follows that the grade of rock in any particular phosphate pit will be influenced by the grade of the pebble in the bed rock stratum from which it chiefly received its supply of pebble, the grade being further modified as already stated by washing and sorting in connection with the redeposition of the pebble.

Still another factor that is even more difficult to estimate is that of secondary enrichment of the rock after it has reached its present location. That the secondary enrichment of the pebble has been more effective at some localities than at others is doubtless true, even though the particular conditions that have brought about this result may not be understood. This subject is discussed in a succeeding paragraph.

SINK HOLES.

Sink holes, although not numerous in the land pebble phosphate beds, are occasionally met with in mining, one such having been seen by the writer in the pit of the Pierce Phosphate Company at Pierce. The break in this sink is through both the overburden and the phosphate bed, as is shown not only by the fact that the phosphate bed drops abruptly, but by the presence of "slickensides" formed as the clay moved downward into the sink.

STREAM BEDS.

In the same pit and near the sink, an old stream bed was cut through in mining. In the bed of the stream is found fine, loose, more or less well stratified sand, which is usually dark, although in places it is gray or light colored. This stream had cut down to the phosphate matrix, and at one point had almost cut out the coarse or upper part of the deposit; in other words the stream had cut almost entirely through the Bone Valley formation. Subsequently owing to changed conditions the stream valley had been filled with sand. It is quite possible that both the sink hole and the stream bed were formed during the time of the Pleistocene elevation when the land stood higher than at present.

CLAY BEDS BENEATH THE PEBBLE PHOSPHATE CONGLOMERATE.

In pit No. 10 of the Prairie Pebble Phosphate Company near Mulberry, some 12 or 15 feet of clay matrix carrying but little phosphate was found to lie beneath the pebble conglomerate, the sump hole of the pit being sunk into the clay. This clay matrix apparently does not represent the bed rock but belongs with the Bone Valley formation. The accumulation of this amount of clay with little coarse pebble may be readily understood. Doubtless this particular depression was so located that when the area was partially submerged it did not receive the strong wash of either waves or stream currents, but received only the clay or mud from the wash of the surrounding lands. These conditions continued until some 12 or 15 feet of mud with little coarse material accumulated at this spot. Afterwards, however, the conditions changed somewhat so that a conglomerate of pebble accumulated of sufficient thickness to form the workable beds of the pit. Similar conditions may be expected at other localities.

SAND AND FINE PEBBLE BENEATH THE PEBBLE PHOSPHATE CONGLOMERATE.

In one of the pits of the Pierce Phosphate Company that was being worked some years ago, there were to be observed lying beneath the workable phosphate beds, one to three feet of quartz sand intimately mixed with black phosphate pebble. A deposit of this kind lying near the bed rock is not uncommon, and by the miners is called "pepper and salt." As in the case of the clay beds the "pepper and salt" is evidently the result of local conditions. The material in this particular case was fairly well sorted, the sand grains and the minute phosphate pebble being of approximately the same weight.

IRON ROCK IN THE OVERBURDEN

Occasionally the overburden, or several feet of it next beneath the soil, becomes firmly cemented. Under these conditions the rock may become very hard necessitating blasting. The cementing substance in most instances is iron oxide, carried into the sand by surface water. This phase of the overburden was observed in the pit of the Florida Mining Company near Mulberry, where the section was as follows:

1.	Incoherent sand and soil	6 feet
2.	Indurated sands, reddish in color and probably cemented with iron oxide	10 feet
3.	Phosphate bed	15 feet
4.	Yellow marl, "bed rock."	

INCOHERENT SURFACE SANDS AND SOIL.

The loose surface sands are believed to have been derived by disintegration from the phosphatic sands beneath. Accordingly they are found to be variable in thickness depending upon the local conditions. As a rule an irregular line produced by decay separates the loose sands from the more or less indurated sands beneath. At places, however, the phosphatic sand passes gradually into the surface sand and soil.

HARDPAN IN THE SUB-SOIL.

Hardpan which is frequently present in the sub-soil consists as a rule of sand held together more or less firmly by either organic matter or iron oxide acting as a cement. The hardpan is prevailingly dark brown or chocolate colored and may be from two to several feet in thickness.

VESICULAR AND CALCAREOUS SAND ROCK.

Occasionally the phosphatic sand rock of the overburden is found to be vesicular and calcareous. This phase of the formation was observed in the pit of the Dominion Phosphate Company, and in one of the pits of the Medulla Phosphate Company.

OVERBURDEN ABSENT OR REDUCED IN THICKNESS.

It is not unusual to find the overburden locally much reduced in thickness, and in some instances entirely absent. This is due evidently to surface wash and erosion which has removed the sands of the overburden, and in some instances has cut into the phosphate beds. Elsewhere the overburden increases in thickness and finally reaches a point beyond which the phosphate beds under present conditions cannot be economically worked.

BOG IRON ORE IN THE OVERBURDEN

Local small deposits of bog ore are not uncommon. These are found near the surface and as a rule mark the location of small ponds. An unusual phase of iron rock lying practically at the surface is that seen in pit No. 4 of the Phosphate Mining Company one half mile northeast of Mulberry where the rock although hard, contains many cavities.

SECONDARY ENRICHMENT IN THE PHOSPHATE BED.

The manner of accumulation, structural details, and local variations of the land pebble phosphates having been described, there yet remains for consideration the very important factor of secondary enrichment within the bed itself. That secondary enrichment has occurred in the phosphate bed is shown by the fact that the phosphate pebbles washed from the bed rock contain only from 42 to 58 per cent tri-calcium phosphate, while those washed from the phosphate bed contain from 66 to 77 per cent tri-calcium phosphate. In fact this tendency to phosphatization is general in the beds, and with the exception of oyster shells and pieces of wood, which are silicified, has affected the pebbles and rock fragments, the bones and teeth of vertebrates, and the casts of the invertebrates.

The agency through which secondary enrichment has been accomplished in this formation is with little doubt the surface waters which move downward through the phosphatic sands of the overburden, and laterally through the phosphate bed. A similar process contributed as has been shown in a previous paper to the enrichment of the hard rock phosphate.

Secondary enrichment of phosphate rock is doubtless due to the fact long since demonstrated by Reese* that when waters holding calcium phosphate in solution, come in contact with calcium carbonate, a reaction takes place by which the phosphate replaces the carbonate. In view of this fact it seems not at all impossible that the phosphate pebbles of the bed rock itself may have their origin on this process of enrichment, the original pebbles of sandy marl having under favorable conditions become phosphatized possibly from phosphoric acid in solution in the sea water.

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*Chas. L. Reese, Amer. Journ. Sci., 3rd Ser., Vol. 43, p. 402, 1892.

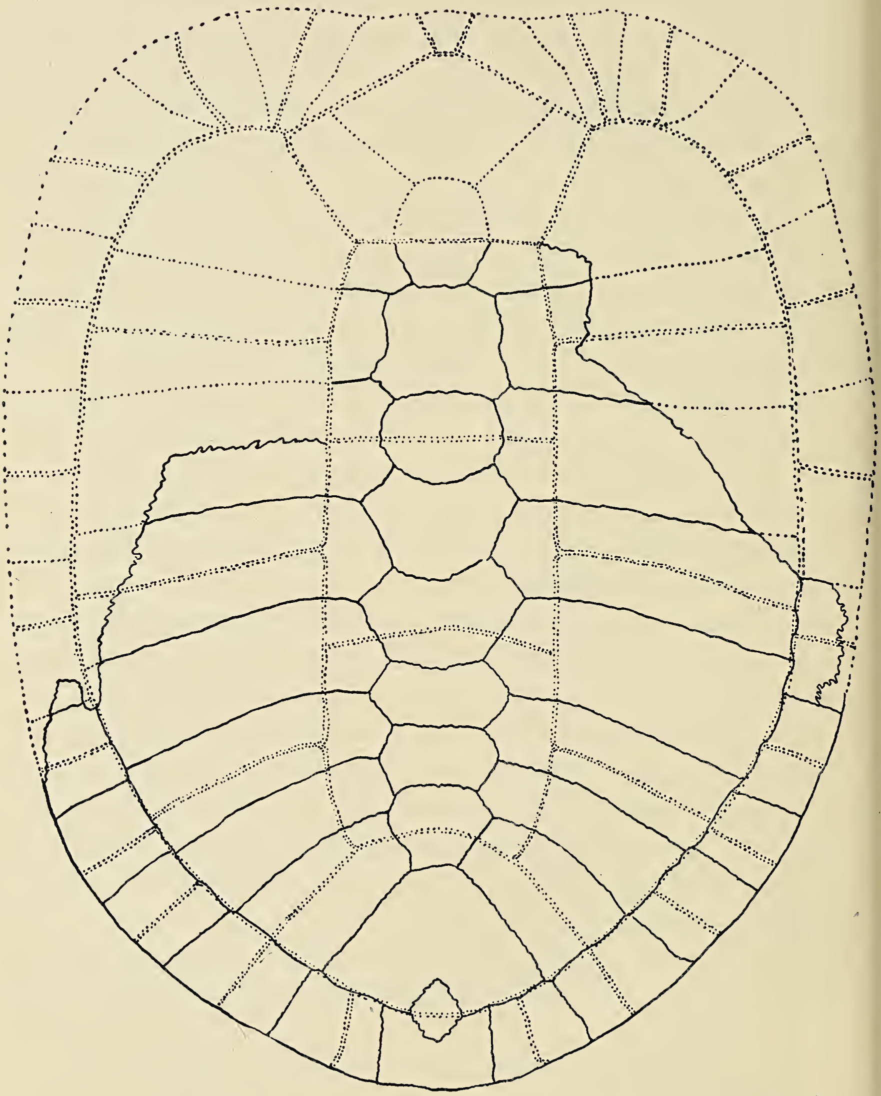

Fig. 7.—Top view of a land tortoise found in pit No. 5 of the Phosphate Mining Company, Nichols, Fla. The front part of the carapace is wanting having been destroyed at the time the specimen was imbedded. The part of the carapace restored in the drawing is indicated by dotted lines. A part of the plastron is also preserved. Fla. Geol. Surv. collection No. 5001. One-twelfth natural size. Donated by the Phosphate Mining Company.

FOSSILS OF THE LAND PEBBLE PHOSPHATE DEPOSITS.

It is not the writer's purpose to include in this paper a descriptive or monographic treatment of the fossils of this formation. It is necessary, however, in order to fully understand the beds, to make mention of the common fossils and to account for the association of land and marine forms, as well as for the inclusion within the beds of fossils of different geologic periods.

The fossils of the land pebble phosphate deposits include: (1) Those that were derived from the underlying formations and hence represent animals that lived at a time antedating the phosphate-bearing formation; and (2), those that are contemporaneous with the formation, having lived at the time when the phosphate beds were being accumulated. It is sometimes assumed that the fossil bones found in the phosphate beds are the source of the phosphoric acid. This assumption obviously is entirely erroneous.

FOSSILS DERIVED FROM THE "BED ROCK."

The fossils from the "bed rock" in this formation include chiefly teeth of sharks and rays, worn pieces of ribs, casts of invertebrates, and silicified corals. Of these fossils the sharks' teeth and silicified corals are highly resistant; the pieces of ribs also, have sufficient endurance to withstand removal from one formation to another The casts of the invertebrates although not particularly resistant will nevertheless withstand fully as much attrition as the fragments of the "bed rock" marl with which they are associated. Since these fossils are found in the "bed rock" marl it is scarcely to be doubted that some of them now found in the phosphate beds were derived from that formation.

FOSSILS FROM MIOCENE STREAM AND RIVER DEPOSITS.

The geologic history of southern Florida leads to the belief that the upper Oligocene marl, the "bed rock," was exposed as a land surface during a part or all of the Miocene period. If this is true, it is evident that residual material, stream and river deposits were accumulated during that time in which doubtless the remains of Miocene land animals were preserved. If so, it is apparent that when the area was again submerged, the more resistant of the Miocene fossils may have been included along with other residual materials in the pebble phosphate conglomerate. While this is recognized as a possible source of certain of the Miocene forms of the land pebble phosphate conglomerate, the study of the fauna has not progressed far enough to permit one to determine whether or not any considerable number of the fossils were so derived.

FOSSILS CONTEMPORANEOUS WITH THE PHOSPHATE DEPOSITS.

The fossils representing animals contemporaneous with the phosphate deposits include both land and aquatic forms. The land animals in the beds no doubt represent forms that were washed in from the nearby shore, or were carried in by streams, while the aquatic forms are those that inhabited the shallow waters in which the beds were accumulating.

LAND FOSSILS OF THE PHOSPHATE BED.

The land animals of the land pebble phosphate beds include mastodons, rhinoceroses, horses and land turtles. The mastodons found in this formation are not unlike the form described by Leidy from near Archer as *Mastodon* (*Trilophdon*) *floridanus*. The parts commonly found include teeth, vertebrae, broken ribs, and occasional leg bones. Skulls are seldom preserved. The mastodon teeth found in the deposits present considerable variation and it is probable that more than one species is represented.

Rhinoceroses are found in this formation, two or more species being present. According to Mr. James Gidley *Teleoceras fossiger* has been definitely identified by him from a tooth obtained from this formation near Mulberry.* On the other hand specimens representing parts of the jaws and teeth presented to the Survey by the Amalmagated Phosphate Company are clearly distinct from *T. fossiger*.

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*Statement before the Palaeontology Society, Dec., 1914.

The presence of rhinoceroses in the formation is believed to establish definitely the fact that the beds cannot be later than early Pliocene, since rhinoceroses in America apparently did not survive beyond that time.

A few horse teeth have been obtained from the pebble phosphate beds, all of which are referable to the genus *Hipparion,* horses of the modern genus *Equus* not being present.

The tree trunks which are occasionally found silicified both in the phosphate beds and the overburden no doubt floated in from the nearby shore, or were carried in by streams. The cellular structure of the wood is not well preserved and the species has not been identified.

Turtle remains are found not infrequently in the Bone Valley formation. As a rule scarcely more than fragments or plates from the carapace are found. The Phosphate Mining Company, however, fortunately recovered a considerable part of the carapace and plastron of a very large land tortoise from their pit at Nichols. This specimen has been presented to the State Geological Survey and is preserved in the State Survey collection. An illustration of the specimen is given on page 70.

MARINE AND ESTUARINE FOSSILS OF THE PHOSPHATE BEDS.

The marine fossils of the phosphate beds include several vertebrate types and a few invertebrates. The aquatic vertebrates in the formation include cetaceans, crocodilians, and fishes. The most common cetaceans are long snouted forms belonging probably in the family Platanistidae. Fragments of the skull and jaws, and also the vertebrae are not uncommon. It seems probable also that the broken ribs found in such abundance in the phosphate beds pertain to these small cetaceans.

Crocodilian teeth, vertebrae and bones are not uncommon in the phosphate beds, and the members of this order were no doubt abundant in the shallow waters in which the land pebble phosphates were accumulating. Among the best preserved of the specimens that have been obtained is a part of the upper and lower jaw of a gavial from the pit of the Amalgamated Phosphate Company, presented by the Company to the State Geological Survey. The species being new, the writer has suggested for it the term *Tomistoma americana.** The discovery of these fossils in the Bone Valley for-

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*A New Gavial from the Late Tertiary of Florida. Amer. Jour. Sci. xl, Aug., 1915.

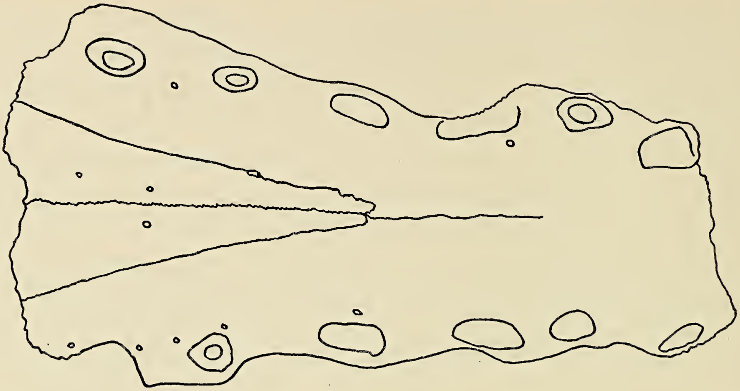

Fig. 8.—*Tomistoma americana* Sellards, a gavial found in the land pebble phosphate deposits. Approximately one-third natural size. Fragment of the lower jaw.

mation is of interest since it affords evidence of the existence of gavials in North America as late as the Miocene or early Pliocene, although they have since disappeared from the Western Hemisphere, the modern gavials being found in Asia and Africa. That the species found in the pebble phosphate beds is to be placed with the gavials rather than with the crocodiles is indicated not only by the long narrow snout, but also by the fact that the first mandibular tooth bites on the outside and not in the inside of the upper jaw.

The fish remains in the phosphate bed include chiefly teeth of sharks and rays. Sharks' teeth in particular are extremely abundant. It is difficult, however, to determine whether the teeth are from sharks that were living at the time the phosphate pebble accumulated, or represent teeth residual from the marl beneath. Since the sharks' teeth are highly resistant they would readily withstand the slight amount of erosion incident to their reaccumulation in the phosphate beds without showing any appreciable attrition, and it seems probable that most of these teeth have been washed in from the "bed rock." The range of the species of sharks as identified by their teeth is considerable, and it is doubtful if it can be definitely determined whether the teeth in this formation are those of Oligocene, Miocene or Pliocene sharks. Plates from the teeth of the rays are also found both in the "bed rock" and in the phosphate beds. It is very probable that the teeth of sharks and rays taken from these beds represent a mixture of Oligocene and Pliocene forms.

Phosphatized casts of invertebrates are rather numerous in the phosphate beds. Most, if not all of these, however, are washed in, as previously stated, from the bed rock beneath. Among the invertebrates in the phosphate beds, which seem to be contemporaneous with the deposits, are silicified oysters found in the pit of the Pembroke mine of the Coronet Phosphate Company, where they occur in some abundance making up a well marked stratum within about two feet of the top of the workable phosphate bed. Dr. W. H. Dall of the U. S. National Museum who has kindly examined specimens of this oyster writes that it is probably *Ostrea mauriciensis* Gabb, differing from the ordinary *O. virginica* by the deep pit under the hinge line.* The two species, however, are very closely related.

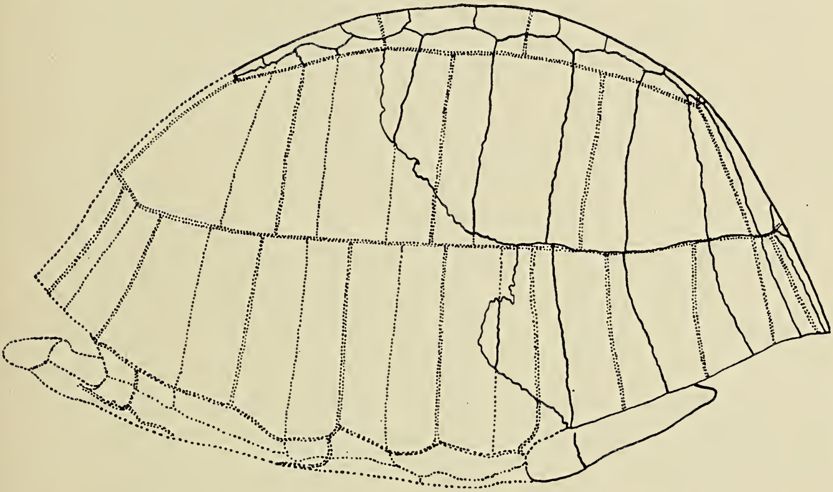

Fig. 9.—Side view of land tortoise. Same specimen as figure 7. One-twelfth natural size. The part restored is indicated by dotted lines.

If this oyster is *O. mauriciensis* it would seem that it must have been washed into this formation from the Alum Bluff formation. However, from the fact that the oysters occur in abundance, and in some cases in large masses near the top of the workable phosphate bed, it seems probable that they actually belong to the Bone Valley formation. *O. mauriciensis,* it may be noted (Dall, Bull. 90, p. 123, U. S. Nat. Mus.) is itself a species of doubtful validity.

The fossils that have been obtained from the formation indicate that the land pebble phosphate deposits were accumulated during either late Miocene or early Pliocene time.

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*Letter of May 14, 1915.

THE RIVER PEBBLE PHOSPHATE DEPOSITS.

The river pebble phosphates are found in Florida in varying amounts wherever streams have cut their channels into the phosphatic marls either of the Alum Bluff or of the Jacksonville formation, or across the phosphate conglomerate of the Bone Valley formation. The pebbles may be found in recent bars in the streams, or in the bars of an earlier channel or valley. The age of the deposits, therefore, on any one stream, may range from Pleistocene or earlier to recent. The immediate origin of these local river deposits is obviously the formation across which the stream flows. In grade the river pebble deposits seldom exceed 66% tri-calcium phosphate.

FOSSILS FROM THE RIVER PEBBLE PHOSPHATE DEPOSITS.

The vertebrate fauna of the river pebble phosphate deposits of Florida includes elephants, mastodons, horses of the genus *Equus,* bison, deer, tapir, manatee, sloths, glyptodonts, and armadillos. With this assemblage of clearly Pleistocene forms is associated in some localities probably by accident the Pliocene horse *Hipparion.* The deposits contain also cetaceans, turtles, crocodiles and fishes.

Elephants were present in Florida during the Pleistocene and possibly during a part of the late Pliocene, their remains being found at many localities throughout the State in the river pebble phosphate deposits and elsewhere. The Florida elephant has usually been identified as *Elephas columbi* Falconer. It would seem, however, that the enamel folds or plates in the teeth are coarser and farther apart than are those of *E. columbi.* According to Lucas* the number of cross folds in the teeth of *E. columbi* average eighteen in a space of ten inches, while in the teeth of the Imperial elephant the cross folds average twelve in the same space. The number of cross folds or plates in the elephant teeth that have been obtained by the writer from Florida will seldom exceed twelve to fourteen in a space of ten inches.

The mastodon commonly found in the river pebble phosphate deposits is that known as the American mastodon, *Mammut americanum,* a species that extended during Pleistocene time over a considerable part of North America. This mastodon is distinguished from those found in the land pebble phosphate deposits by the fact that the valleys across the teeth as seen on the unworn grinders, are open, not being blocked by buttresses from the conules. The tusks likewise lack the band of enamel which characterizes the earlier mastodons. Associated with the American mastodon in the river pebble phosphate deposits may be found occasionally teeth of the earlier forms washed in from the older formations. This association is found, however, only in streams that cut across the Pliocene or Miocene formations.

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*Md. Geol. Surv. Volume on Pliocene and Pleistocene, p. 159, 1906.

Horses of the genus *Equus* were present in Florida during Pleistocene and possibly also during the late Pliocene, their remains being found in numbers in the river pebble phosphate deposits and elsewhere throughout the State. The parts preserved include for the most part the teeth and occasional bones. Several species of Pleistocene horses have been described from Florida as follows: *Equus caballas, E. leidyi* and *E. littoralis.* Associated with the horses of this modern genus is found in the river pebble deposits horses of the extinct genus *Hipparion.* As in the case of the mastodon this association is noted only in the bed of streams that cut into Pliocene formations.

The bison obtained from the river pebble phosphate deposits represents an extinct species, probably *Bison latifrons.* The deer, tapir and manatee, however, are scarcely distinguishable from the living species.

The sloths, now confined to South America, extended in Pleistocene time over a considerable part of the United States, their remains being found at different localities throughout the State in the river pebble phosphate deposits and elsewhere. Glyptodonts, a division of the *Edentates* now extinct, likewise extended their range into North America during Pleistocene time. They are found in Florida in the river pebble phosphate deposits and at some other localities.

Armadillos, or armadillo-like animals, are represented in the Florida Pleistocene by the genus *Chlamytherium,* which in some respects is intermediate between the Glyptodonts and the Armadillos. Parts of the skeleton or plates from the carapace of a species of this genus have been obtained from Peace Creek, White Beach, Hillsboro River, and Vero. Distinctive characters of the genus are found in the molar teeth which are elongated from front to back, the larger teeth being two or three times as long as broad. On the exterior of the tooth is a broad deep furrow which partially divides the crown into an anterior and posterior pillar. On the inner surface of the tooth is seen two or three faint furrows, which, however, scarcely appear on the crown. The cross section of the molar is thus that of an ellipse slightly compressed at the center more strongly so from the outer side.

The lower jaw is more or less pointed in front and contains nine teeth. Of the teeth the posterior six are molariform in appearance and function, while the anterior three are reduced and are more nearly circular in across section. In general appearance the jaw is distinctly glyptodont. From the glyptodonts, however, the genus is distinguished not only by the structure of the teeth which lack the tripartite division of the crown and base, but by the fact that the ramus of the jaw is inclined gently backward, and does not turn up at a right angle, or more than a right angle as in the glyptodonts. Moreover, the shield consists of an anterior and posterior buckler with several movable transverse bands between similar to those of the armadillos. Although referred to the Dasypoda, the genus is recognized as in many ways intermediate between the armadillos and the glyptodonts.*

LOCAL DEPOSITS OF RIVER PEBBLE PHOSPHATE.

The localities in the State where small deposits of river pebble phosphates have accumulated are rather too numerous to describe separately. A number of the important localities, however, may be referred to. For the location of the deposits see the map on page 30.

PEACE CREEK.

Peace Creek originating in the northern part of Polk County, flows south across both the Alum Bluff phosphatic marl and the land pebble phosphate deposits. The conditions for the accumulation of pebble phosphate in the valley of this stream, therefore, have been particularly favorable, and it is on this stream that the most extensive river pebble phosphates in Florida have been found. The Peace Creek beds have also a historic interest since it was here in 1888 that phosphate mining in Florida began.

Owing doubtless to the mixed condition of the fossils, some difference of opinion has been expressed as to the age of the Peace

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*Sellards, E. H., *Chlamytherium septentrionalis,* an Edentate from the Pleistocene of Florida. Amer. Journ. Sci. Vol. xl, Aug., 1915.

Creek beds. From his examination of these beds in 1891 Dr. W. H. Dall was led to believe that, on the evidence of stratigraphy and invertebrate Palaeontology, the beds were to be referred to a mid-Pliocene stage.* The account given by Dall, however, does not appeal to the writer as being conclusive on this point. At the mouth of Mare Creek, six miles above Arcadia, Dall observed a marl, designated by him as the Arcadia marl, from which, however, no characteristic fossils were obtained. Lying upon this marl was observed a calcareous and phosphatic sand rock, which was identified from the marine shells that it contained as lower Pliocene. With this phosphatized rock is associated a bone bed. Dall states (l. c., p. 132) "The mammalian bones at this point appear to lie on this stratum, and where it is broken up, as is most commonly the case, are mingled with its fragments and blackened in the same way." Three miles down stream at Singleton's Landing an oyster bar was observed which proved from its invertebrate fauna to be late Pliocene. Moreover, near Zolfo Springs, this marl was observed to overlie the "phosphate stratum." From these exposures Dall was led to believe that the Peace Creek bone bed lay between the lower Pliocene phosphatic sand rock and the upper Pliocene shell marl.

It is to be noted, however, that the bone bed is found on top of the phosphatic sand rock, and that there is no evidence that the bone bed is present beneath the upper Pliocene shell marl. It is true that the upper Pliocene is reported to overlie the phosphatic stratum at Zolfo Springs. It is not shown, however, that the bone bed is present between the upper Pliocene and the phosphatic sand rock.

It is apparent that both Pliocene and Pleistocene deposits lie along Peace River, and have been and are being reworked and reaccumulated by stream action. It necessarily follows, therefore, that the fossils of these formations, or such of them as are sufficiently resistant to withstand slight erosion, are intimately mixed in the deposits along the river. Moreover, since Peace River cuts into the Alum Bluff marl it is to be expected that some of the resistant fossils from that formation, particularly sharks' teeth, have persisted in the river pebble deposits. It is hardly necessary to add that only under very exceptional circumstances can a formation be older than the latest of the fossils that it contains.

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*U. S. Geol. Surv. Bull. 84, pp. 130-133, 1892.

The following section is found on the east bank of Peace River about three hundred yards up stream from the Brownsville Bridge, and one-half to three-quarters mile above the Mare Creek section.

1.	Soil and incoherent gray sand	4 feet
2.	Yellow sand, somewhat indurated	5 feet
3.	Fine black phosphate pebble, interbedded with sand, and containing also leaves, branches and partly decayed logs to water's edge	3 feet

This exposure is clearly a river deposit, and can hardly be older than Pleistocene. From this exposure in addition to the decayed wood and leaves was taken the usual Peace Creek fossils including teeth of the elephant, *E. columbi,* tooth of the deer, *Odocoileus,* broken ribs and teeth of sharks and rays.

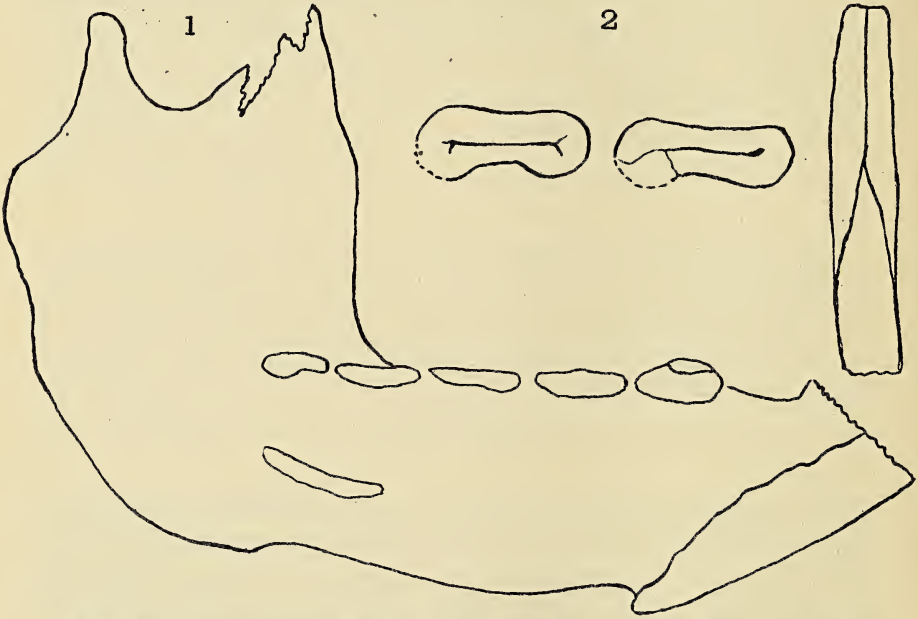

Fig. 10.—*Chlamytherium humboldtii,* left jaw, interior view. A tracing taken from Lund's original illustration. One-half natural size. Introduced for comparison with specimens found in Florida. (2) *Chlamytherium septentrionalis.* Two teeth from the right lower jaw. At the left, the third tooth from the back of the jaw (presumably the seventh from the front); the grinding surface of the tooth measures 22 by 6 mm. At the center, the fourth tooth from the back, (presumably the sixth from the front); the grinding surface of the tooth measures 23 by 6 mm. At the right, median section through the fourth tooth from the back of the jaw, showing by diagrammatic section the cavity at the base of the tooth. All from specimen No. 1722, Fla. Geol. Surv. Natural size. From Vero, Fla.

The fossil vertebrates identified by Dr. Leidy from the river pebble phosphates on Peace Creek, include the following:* *Tapirus terrestris* (*T. americanus*); Equus sp.; *Hipparion* (*Hippotherium*) *ingenuum; Hipparion plicatile;* an upper molar tooth compared with *Bison americanus;* Antler bones and teeth of deer not differing from those of *Odocoileus* (*Cervus*) *virginianus; Elephas columbi; Chlamytherium septentrionalis* (*Chlamydotherium humboldtii*); dermal plates resembling those of *Hoplophorus euphractus; Glyptodon petaliferous; Megalonyx jeffersonii; Manatus antiquus;* several cetaceans; *Emys euglypha;* one or two species of *Trionyx; Testudo crassiscutata;* two vertebrae of a large serpent; dermal plates of a crocodile; *Ephippus gigas;* dermal turbercles of ray; and teeth of *Diodon, Myloiobates, Oxyrhina,* and *Galeocerdo.*

Of the species of this list several evidently represent fossils washed in from the Alum Bluff and Bone Valley formations through or into which the stream has cut its channel. This applies to some at least of the fish teeth. The *Hipparion* remains in these beds are probably also derived from the older formations. The teeth of this horse are quite resistant to erosion and although rather numerous in the Peace Creek beds it is probable that they have been carried into the deposits either from the reworking of Pliocene stream deposits immediately along the river or from the land pebble phosphate deposits, across which the stream flows and in which Hipparions are found. This view is supported by the fact that the teeth of *Hipparion* are found in the deposits in all stages of erosion, in many instances reduced to a mere fragment of their former size. Moreover, *Hipparion* in association with the Pleistocene fauna is obtained in Florida only from those streams that cut across Pliocene beds. At some other localities, notably at Vero in St. Lucie County, the Peace Creek Pleistocene vertebrate fauna is found in a stream that flowed across early Pleistocene shell marl deposits. From this locality no *Hipparion* remains have been obtained.

ALAFIA RIVER.

Pebble phosphates similar to those in Peace Creek, are found and have been worked to some extent on the Alafia River. This stream originates in the land pebble phosphate area of Polk County and flows west to Tampa Bay. It therefore cuts across the land pebble phosphates and in the lower part of its course cuts into the Alum Bluff marl, from both of which formations the river pebble is derived.

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*Description of Vertebrate Remains from Peace Creek, Florida. Wag. Free Inst. Sci. Trans. Vol. 2, pp. 19-31, 1889.

MANATEE RIVER.

A limited amount of pebble phosphate is found along Manatee River and its tributaries derived largely from the Alum Bluff marl into which the river has cut its channel.

NORTH CREEK.

North Creek in Manatee County affords an interesting illustration of the accumulation of pebble phosphate in successive formations. This stream cuts into the Alum Bluff marl which at this locality contains a considerable amount of phosphate pebbles. Resting directly upon the marl is found a Pleistocene shell marl, which is likewise phosphatic, the pebble having been derived from the Oligocene marl beneath. Finally in the recent bars of the stream is found a mixture of shell, pebble phosphate and sand.

CALOOSAHATCHEE RIVER.

Dark colored phosphate pebbles similar to that on Peace Creek are found in the bed of Orange and Caloosahatchee Rivers in Lee County. That found along Orange River is derived from a yellow phosphatic marl which rises two or three feet above water level. The marl exposed here contains an abundance of large oysters, pectens and other invertebrates. The pebble phosphate of the Caloosahatchee river is probably derived from the same phosphatic marl. If so, however, it lies beneath the typical Caloosahatchee marl and is nowhere exposed above water level. The Caloosahatchee marl, itself, contains occasional phosphate pebble and phosphatized casts of shells, but probably not in sufficient abundance to account for the accumulation of the phosphate in the bed of the river, particularly in the lower course of the stream. The phosphate pebble found in this river and its tributaries is doubtless derived either directly or indirectly from the Alum Bluff formation which although not exposed, probably lies at no great depth below the surface.

BLACK CREEK.

The pebble phosphates on Black Creek in Clay County are derived from the phosphatic marls through which the stream has cut its channels. This marl, as previously stated, has been referred, on the basis of the invertebrate fossils, to the Jacksonville formation.

OLUSTEE CREEK.

Pebble phosphate is found on some of the tributaries of Olustee Creek in Bradford and Columbia counties, and probably in the creek itself. The pebble is derived from phosphatic marls which probably represent the Alum Bluff formation.

ALLAPAHA RIVER.

A limited amount of pebble phosphate is found on the Allapaha River near Jennings in Hamilton County. This pebble is derived without doubt from the Alum Bluff formation.

SOPCHOPPY RIVER.

Pebble phosphate has been found to some extent in the valley of Sopchoppy River and some other streams in Wakulla County, the pebble being derived from the Alum Bluff formation. The local beds of phosphate in Wakulla County were among the first reported in Florida, having been described by Dr. J. Kost in his report to Governor Perry in 1887.

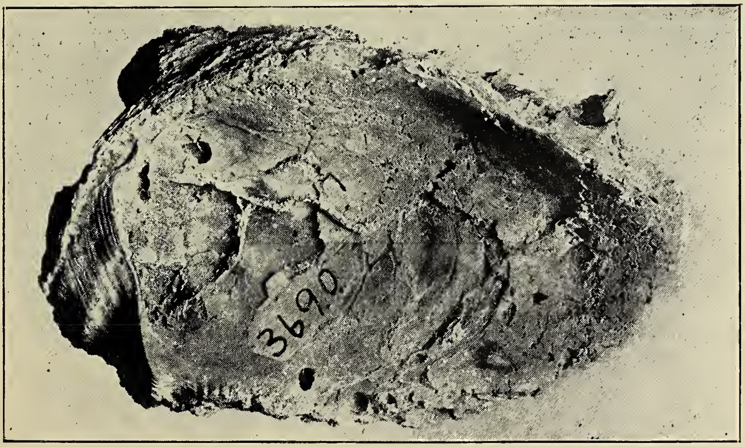

Fig. 11.—*Ostrea* from the Pembroke mine of the Coronet Phosphate Company. Silicified oysters are found at this locality in considerable abundance within about two feet of the top of the workable phosphate bed (Bone Valley formation).

RELATION BETWEEN THE HARD ROCK AND THE LAND PEBBLE PHOSPHATES.

It may be of interest in this connection to note some points of similarity as well as of contrast between the hard rock and the land pebble phosphates of Florida. First of all both the hard rock and the land pebble deposits are contemporaneous in time and are derived from the same source, namely, the phosphatic marls of the Alum Bluff formation. However, in the accumulation of the hard rock phosphate chemical action has predominated, resulting in the formation of boulders of very high grade. The land pebble phosphates on the other hand represent primarily a mechanically accumulated pebble conglomerate, although as in the case of the hard rock, the grade has been subsequently improved by secondary enrichment.

The relation of the deposits to the underlying formations is likewise different. The hard rock phosphates rest upon the Ocala limestone, the upper Oligocene formations having entirely disintegrated. The pebble phosphate deposits on the other hand rest upon the eroded top surface of the Alum Bluff (upper Oligocene) formation.

Land animals are present in some abundance in both formations, but it is only in the land pebble phosphate deposits that such distinctly aquatic forms as cetaceans have as yet been found.*

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*The Zeuglodont taken from the hard rock phosphate deposits referred to on an earlier page is residual from the Ocala formation.

ILLUSTRATIONS.

To Accompany Paper On

THE PEBBLE PHOSPHATES OF FLORIDA.

Figures 12-52.

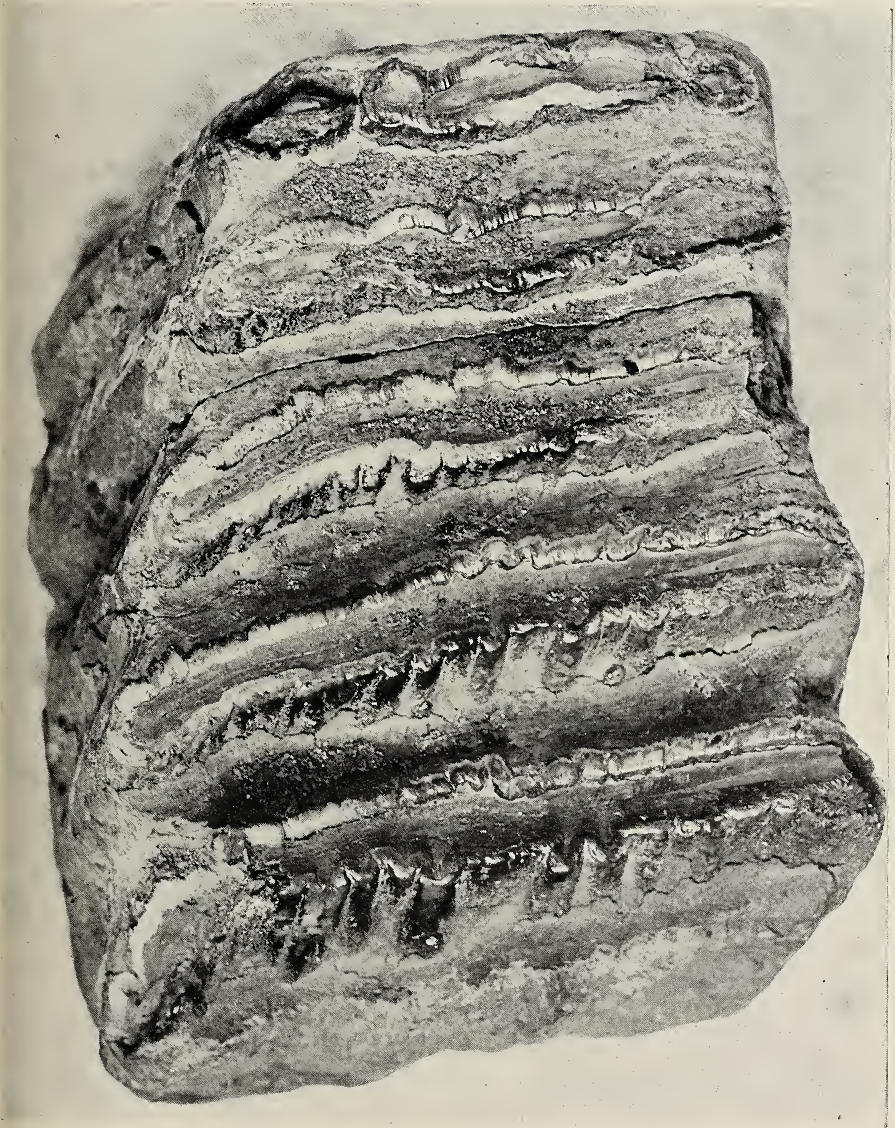


Fig. 12.—A part of the grinding surface of the tooth of the elephant, probably *Elephas columbi* var. Natural size. Fla. Geol. Surv. collection, No. 2234. Dredged from the Withlacoochee River. Width of tooth 8 cm. About five plates per 100 mm. The Florida elephant differs from the typical *E. columbi* in that the plates are much coarser than in that species. This elephant is found in Pleistocene deposits.

VIEW SHOWING EXPOSURE OF THE ALUM BLUFF FORMATION.

Fig. 13.—Alum Bluff on the Apalachicola River. Made from a photograph taken by Dr. E. A. Smith, Oct. 29, 1890. This bluff, at the base of which is found the type exposure of the Alum Bluff formation, is about 166 feet high.

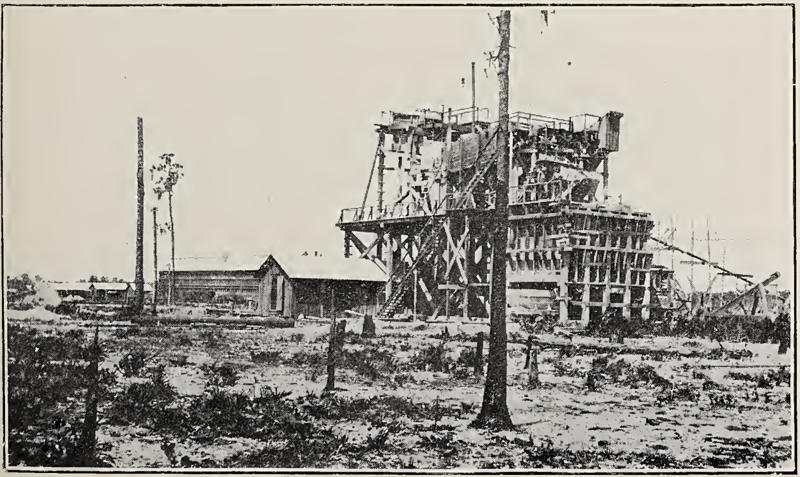
The Alum Bluff formation is extensive in Florida and is exposed at many localities from the Apalachicola River to Sarasota Bay. This formation, which is more or less phosphatic throughout, is of special interest in connection with the phosphate deposits since from it directly or indirectly has been derived the workable phosphate beds of Florida.

VIEWS SHOWING METHODS OF MINING PEBBLE PHOSPHATE IN FLORIDA.

Fig. 14.—View in the pit of the Pembroke mine of the Coronet Phosphate Company, showing in the back ground, removal of overburden by steam shovels. In the foreground may be seen one of the hydraulic guns used in mining the land pebble phosphate. The phosphate rock, together with the matrix, is washed into sump holes and is then pumped through pipe lines to the washer plant.

Fig. 15.—A near view in the same pit. Mining phosphate rock by the hydraulic method. This method is used in many of the mines in removing the overburden as well as in mining the rock.

Fig. 16.—Phosphate washer. View taken at the plant of the Dominion Phosphate Company.

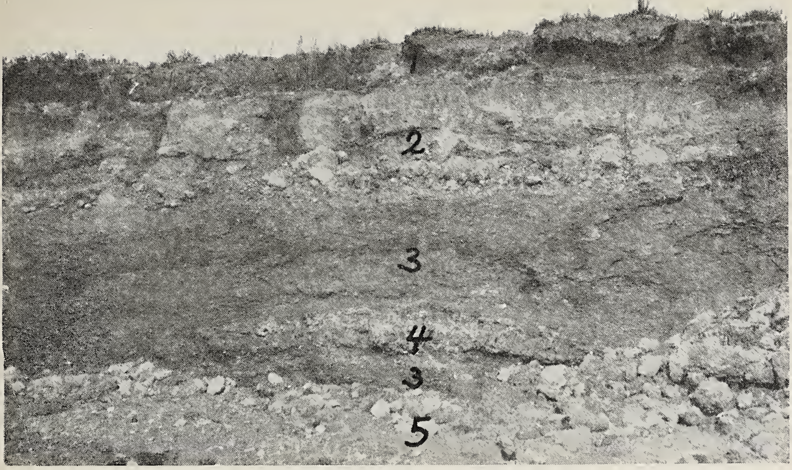


VIEWS SHOWING THE LAND PEBBLE PHOSPHATE DEPOSITS, AND THEIR RELATION TO THE BED ROCK MARL.

Fig. 17.—View in pit of the Palmetto Phosphate Company near Tiger Bay, showing an inclusion near the base of the phosphate bed (Bone Valley formation) of a large mass of the bed rock marl (Alum Bluff formation). (1) Surface soil and loose sand. (2) More or less indurated sands of the overburden. (3) Workable phosphate bed. (4) Inclusion of the Alum Bluff phosphatic marl within the phosphate bed. (5) Bed rock marl.

Fig. 18.—View in the pit of the Pierce Phosphate Company showing the unconformity between the phosphate bed (Bone Valley formation) and the bed rock marl (Alum Bluff formation). (1) Workable phosphate bed. (2) Bed rock marl.

Fig. 19.—General view of the pit and plant of the Pierce Phosphate Company, Pierce, Florida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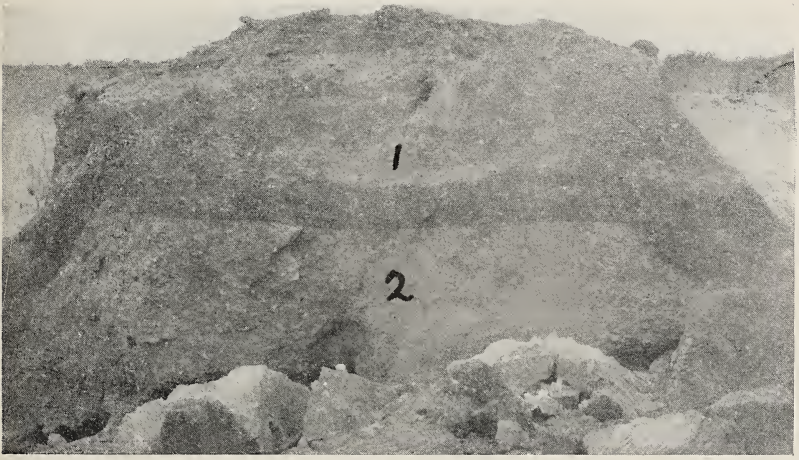
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VIEWS SHOWING CHARACTERISTICS OF THE LAND PEBBLE PHOSPHATE DEPOSITS AND OF THE PHOSPHATIC MARLS WHICH LIE BENEATH.

Fig. 20.—Phosphatic marl. The sample here illustrated was taken from Black Creek. A similar marl, however, lies beneath the land pebble phosphate deposits and is known as the "bed rock."

The analysis of the phosphate pebbles washed from this sample is as follows:

Moisture	.88
Insoluble matter, sand, etc.	18.94
Phosphoric acid, 24.45, equivalent to tricalcium phosphate	53.40
Iron and alumina	0.23
Calcium oxide, 5.07, equivalent to calcium carbonate	11.53

Fig. 21.—Sample from the land pebble phosphate bed showing light colored phosphate pebbles imbedded in the matrix. From the pit of the Prairie Pebble Phosphate Company near Mulberry.

The following is an analysis of this sample of matrix:

Moisture	.78
Insoluble matter, sand, etc.	25.18
Phosphoric acid, 26.73, equivalent to tricalcium phosphate	58.38
Iron and alumina	7.51
Calcium oxide, 1.02, equivalent to calcium carbonate	2.32

The following is an analysis of phosphate pebbles washed from this matrix:

Moisture	1.33
Insoluble matter, sand, etc.	6.87
Phosphoric acid 35.34, equivalent to tricalcium phosphate	77.18
Iron and alumina	0.93
Calcium oxide, 1.39, equivalent to calcium carbonate	3.16

VIEWS SHOWING CHARACTERISTICS OF THE PHOSPHATE PEBBLES OF THE BED ROCK MARL AND OF THE PHOSPHATE BED.

Fig. 22.—Phosphate pebbles, shark and ray teeth washed from the bed rock from the pit of the Phosphate Mining Company near Mulberry.

The analysis of these pebbles is as follows:

Moisture	.94
Insoluble matter, sand, etc.	6.11
Phosphoric acid, 24.88, equivalent to tricalcium phosphate	54.34
Iron and alumina	0.27
Calcium oxide, 7.58, equivalent to calcium carbonate	17.24

Fig. 23.—Phosphate pebbles from the phosphate bed (Bone Valley formation). From the pit of the Phosphate Mining Company, Mulberry.

The analysis of these pebbles is as follows:

Moisture	3.22
Insoluble matter, sand, etc.	.35
Phosphoric acid, 34.73, equivalent to tricalcium phosphate	75.85
Iron and alumina	0.28
Calcium oxide, 3.73, equivalent to calcium carbonate	8.49

VIEWS SHOWING CHARACTERISTICS OF THE PHOSPHATE PEBBLES OF THE BED ROCK MARL AND OF THE PHOSPHATE BED.

Fig. 24.—Phosphate pebbles and cast of a shell washed from the bed rock of the Pierce Phosphate Company, Pierce. The shell cast, which is not phosphatized, is from the bed rock in the pit of the Palmetto Phosphate Company, Tiger Bay.

The analysis of these phosphate pebbles is as follows:

Moisture	.97
Insoluble matter, sand, etc.	10.75
Phosphoric acid, 19.41, equivalent to tricalcium phosphate	42.39
Iron and alumina	0.19
Calcium oxide, 16.79, equivalent to calcium carbonate	38.20

Fig. 25.—Phosphate pebbles and cast of shell washed from the phosphate bed in the pit of the Pierce Phosphate Company. The shell cast is phosphatized.

The following is an analysis of these phosphate pebbles:

Moisture	1.81
Insoluble matter, sand, etc.	6.62
Phosphoric acid, 30.67, equivalent to tricalcium phosphate	66.98
Iron and alumina	1.32
Calcium oxide, 3.05, equivalent to calcium carbonate	6.94

The illustrations of phosphate pebbles show that aside from chemical composition there is no essential difference between the phosphate pebbles of the bed rock marl (Alum Bluff formation) and those of the phosphate bed (Bone Valley formation). The pebbles are similar in size, shape and structure, except that those from the phosphate bed are possibly somewhat more rounded than those from the bed rock. The pebbles from the phosphate bed are without exception higher in calcium phosphate than are those from the bed rock, this increase in tri-calcium phosphate being due to secondary enrichment as stated in the text, page 69.

FOSSILS FROM THE LAND PEBBLE PHOSPHATE DEPOSITS.

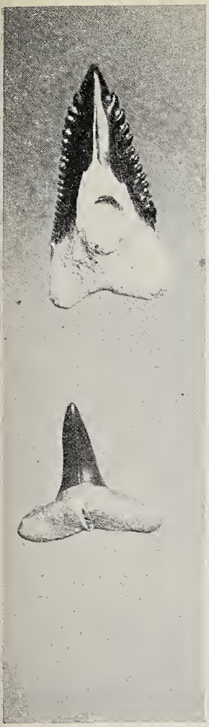
SHARKS.

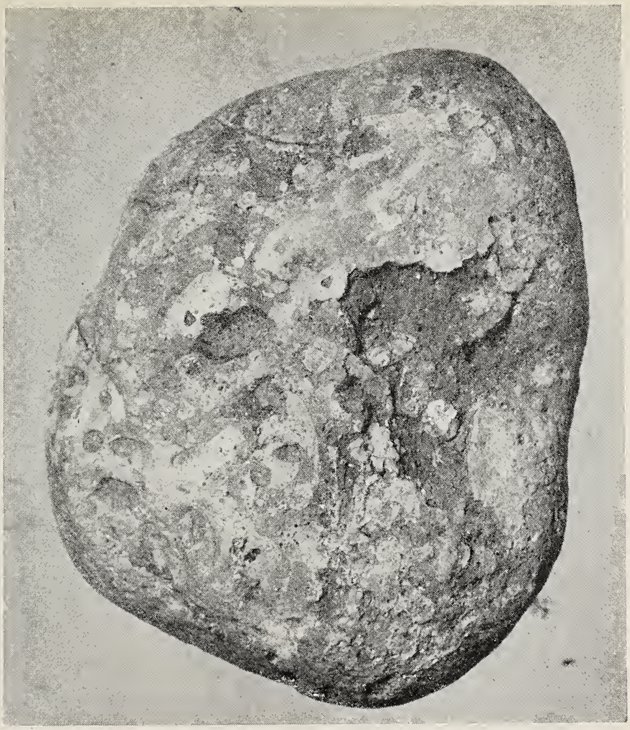
Fig. 26.—Sharks' teeth from the Bone Valley formation. *Hemipristis* above, and *Carcharias* below. Natural size. Fla. Geol. Surv. collection Nos. 825-e and 261-a.

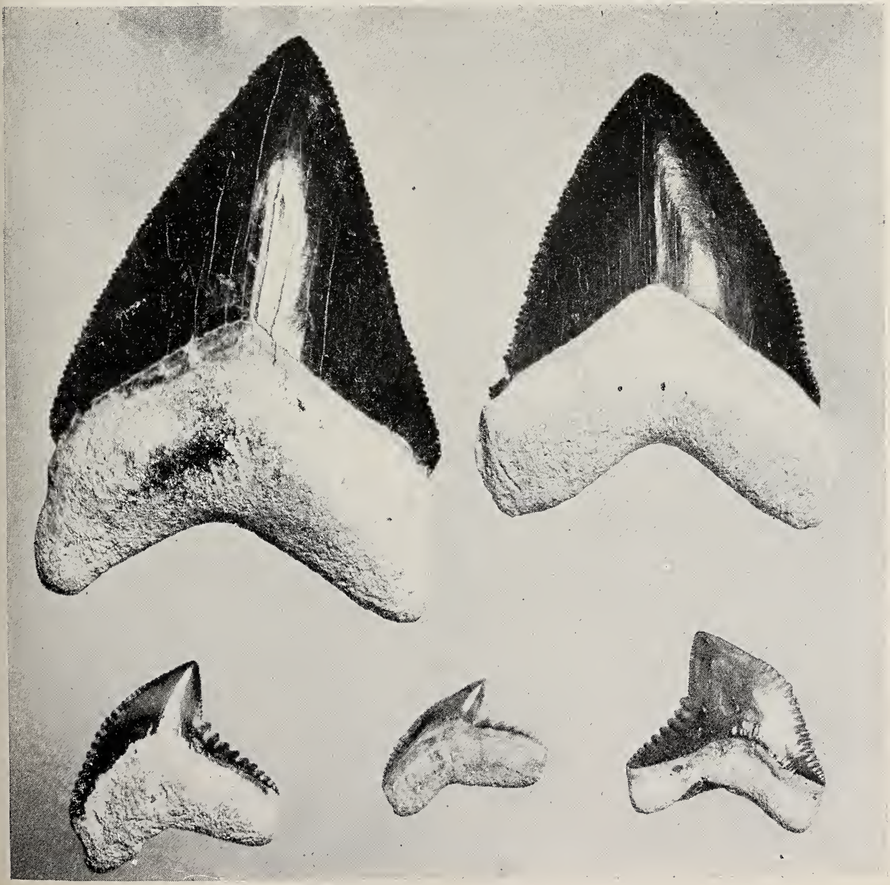
Fig. 27.—A large phosphate pebble from the pit of the Pierce Phosphate Company, Pierce. Something of the structure of the pebble may be seen in the photograph. It is made up of sand grains, minute phosphate pebbles and cast of shells imbedded in the phosphatic matrix.

Fig. 28.—Sharks' teeth from the Bone Valley formation. *Carcharodon* above and *Galeocerdo* below. Natural size. Fla. Geol. Surv. collection Nos. 2305-a, 2561, 825-a, 825-b, 825-c.

Shark and ray teeth are very abundant in the Bone Valley formation. Some of these without doubt were derived from the Alum Bluff formation beneath, while others perhaps, represent sharks and rays that were living at the time the Bone Valley formation was accumulated.







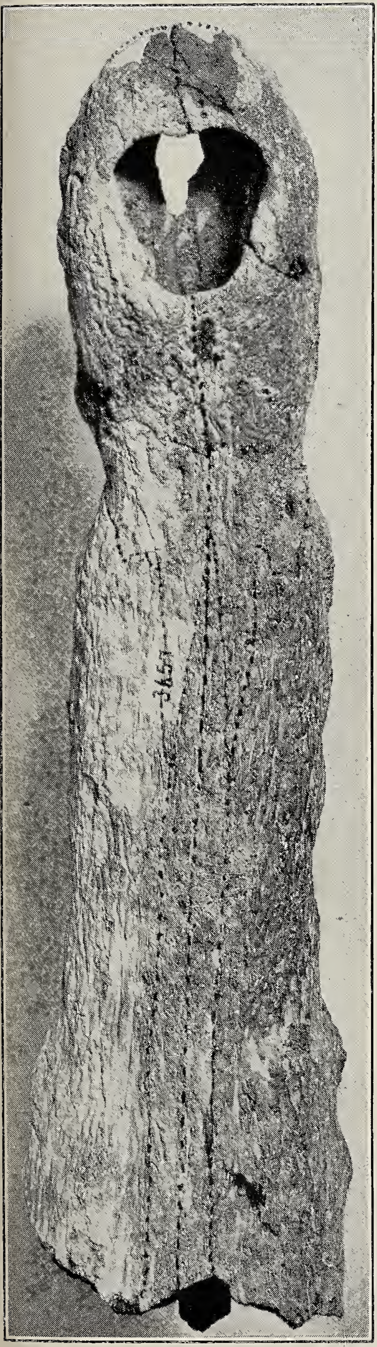
FOSSILS OF THE LAND PEBBLE PHOSPHATE DEPOSITS.

CROCODILES AND GAVIALS.

Crocodilian teeth, vertebrae and bones are not uncommon in the phosphate beds, and the members of this order were no doubt abundant in the shallow waters in which the land pebble phosphates accumulated.

Figs. 29 and 30.—*Tomistoma americana* Sellards. Upper and lower view of rostrum. Sutures not sufficiently evident in the photograph are indicated by dotted lines. Approximately one-third natural size. From the Bone Valley formation, Brewster. Fla. Geol. Surv. collection No. 3657. Length of specimen as preserved 49 cm. The rostrum when seen from the side shows a very slight upward curvature. The notch in the jaw which should receive the first mandibular tooth is feebly developed, being scarcely perceptible; the notch or constriction in the jaw which received the fourth mandibular tooth is, however, well developed. The teeth, the base or sockets of eleven of which are preserved, are sub-equal in size, showing but slight differentiation. Five teeth are present in each premaxillary. The first three maxillary teeth are strong; the fourth, however, is reduced and the jaw at this point is slightly constricted for the reception apparently of two strong mandibular teeth. Back of the fourth maxillary tooth the rostrum is again expanded, the fifth and sixth maxillary teeth being strong. Between these teeth is seen a distinctly marked pit for the reception of a mandibular tooth.

The presence of a gavial in this formation is of interest; it affords evidence of the existence of gavials in North America as late as the Miocene or early Pliocene, although they have since disappeared from the Western Hemisphere, the modern gavials being found in Asia and Africa.



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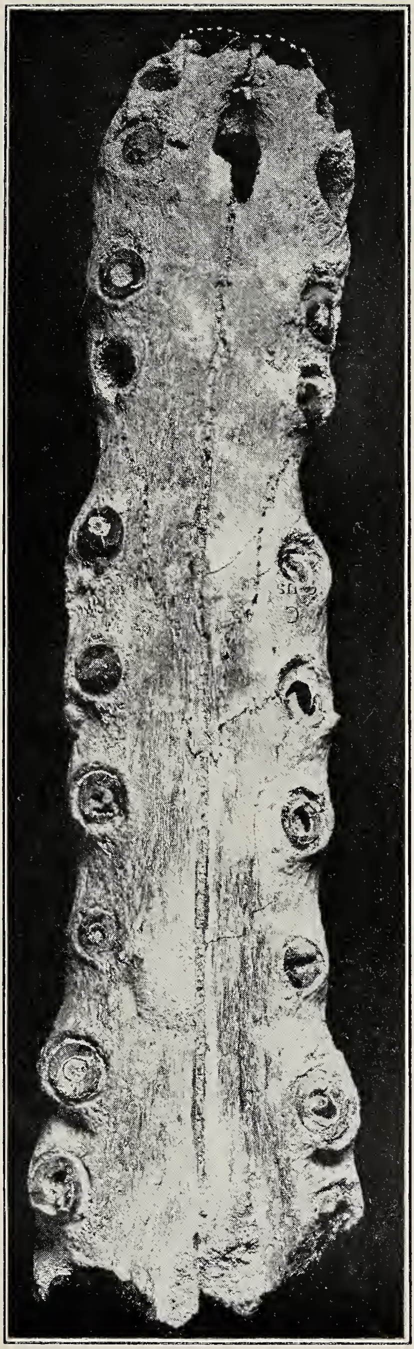


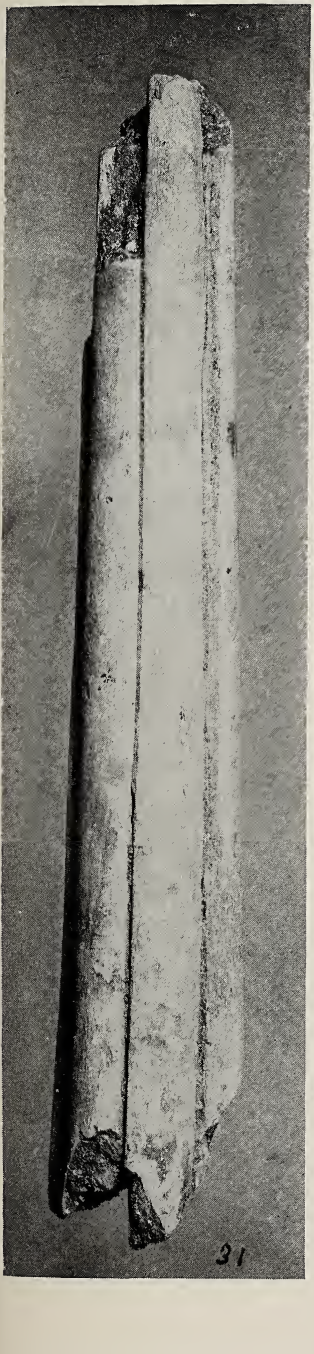
FOSSILS OF THE LAND PEBBLE PHOSPHATE DEPOSITS.

CETACEANS.

Fig. 31.—View of a part of the snout of a small cetacean of the family Platanistidae. Approximately one-half natural size. Fla. Geol. Surv. collection No. 828. From pit of the Dominion Phosphate Company, five miles south of Bartow. Length of specimen as preserved 28 cm, width 42 mm.

Fig. 32.—Side view of upper and lower jaw of another cetacean. Approximately one-half natural size. Specimen in the collection of the Prairie Pebble Phosphate Company, taken from land pebble phosphate bed near Mulberry. Length of specimen as preserved 30 cm, width at center 8 cm.

Small cetaceans of the family Platanistidae are among the most abundant fossils of this formation. Broken ribs of these animals are particularly abundant; vertebrae are found frequently; while parts of the skulls similar to those illustrated are occasionally met with in mining.



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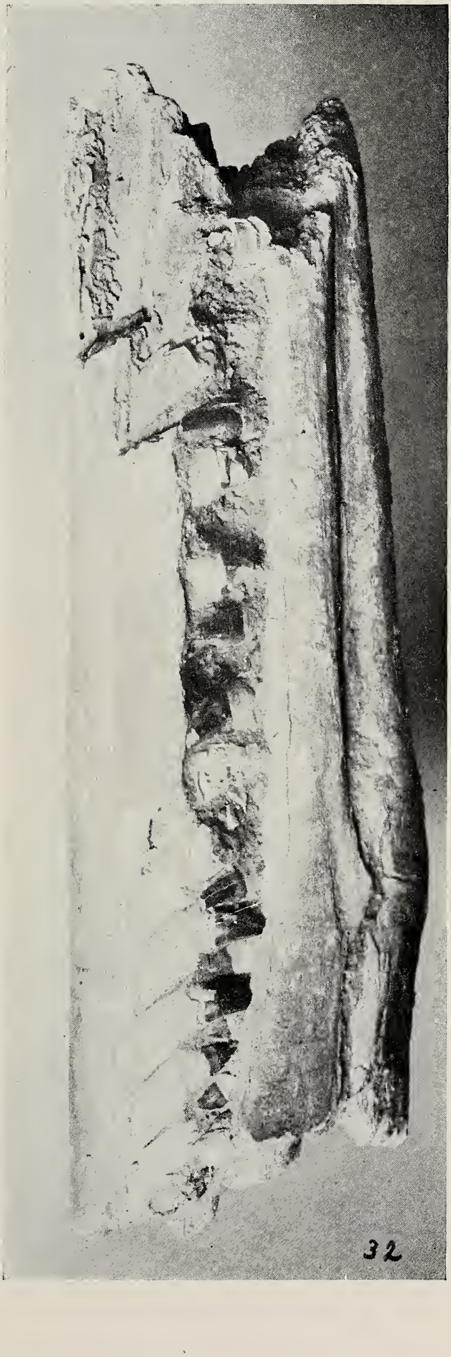

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FOSSILS OF THE LAND PEBBLE PHOSPHATE DEPOSITS.

CETACEAN AND MASTODON.

Fig. 33.—Vertebra of a small cetacean. Slightly more than one-half natural size. From pit of Amalgamated Phosphate Company, Brewster. Fla. Geol. Surv. collection No. 3656. Length of vertebra 14 cm; width 12.5 cm.

Fig. 34.—*Mastodon* (*Trilophodon*) *floridanus* Leidy. Worn upper right molar. Slightly reduced. Fla. Geol. Surv. collection No. 2307. Size of grinding surface of tooth, 114 by 75 mm.

FOSSILS OF THE LAND PEBBLE PHOSPHATE DEPOSITS.

MASTODON AND RHINOCEROS.

Fig. 35.—Mastodon. At the left unworn lower molar. Two-thirds natural size. From pit of the Standard Phosphate Company, Christina, Fla. Geol. Surv. collection No. 2275. At the right slightly worn molar. From Prairie Pebble Phosphate Company, Mulberry. Fla. Geol. Surv. collection No. 4556. No. 2275, 80 by 55 mm; No. 4556, 75 by 85 mm.

Fig. 36.—Tip of the tusk of a mastodon, probably *M.* (*Trilophodon*) *floridanus* Leidy. Approximately two-fifths natural size. The tusk is characterized by a band of enamel by which this mastodon is distinguished from the Pleistocene mastodon, *Mammut americanum*, the tusk of which has no enamel. From pit of the Amalgamated Phosphate Company, Brewster. Fla. Geol. Surv. collection No. 2371. Length of specimen as preserved 26 cm; width 8 cm. Width of band of enamel 49 mm.

Fig. 37.—Lower jaw of rhinoceros from pit of the Amalgamated Phosphate Company, Brewster. Approximately one-fourth natural size. Fla. Geol. Surv. collection No. 3636. Length of molar-premolar series, 26 cm; length of molar series 14.5 cm; crown of third premolar, 38 mm; fourth premolar, 40 mm; first molar, 47 mm; second molar, 50 mm; third molar, 48 mm.

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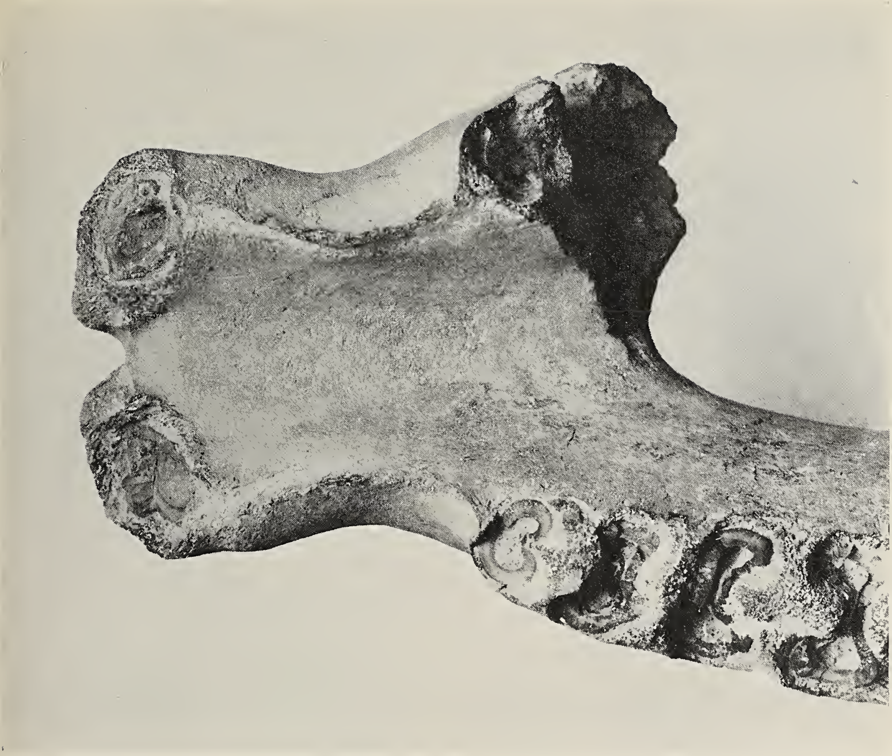
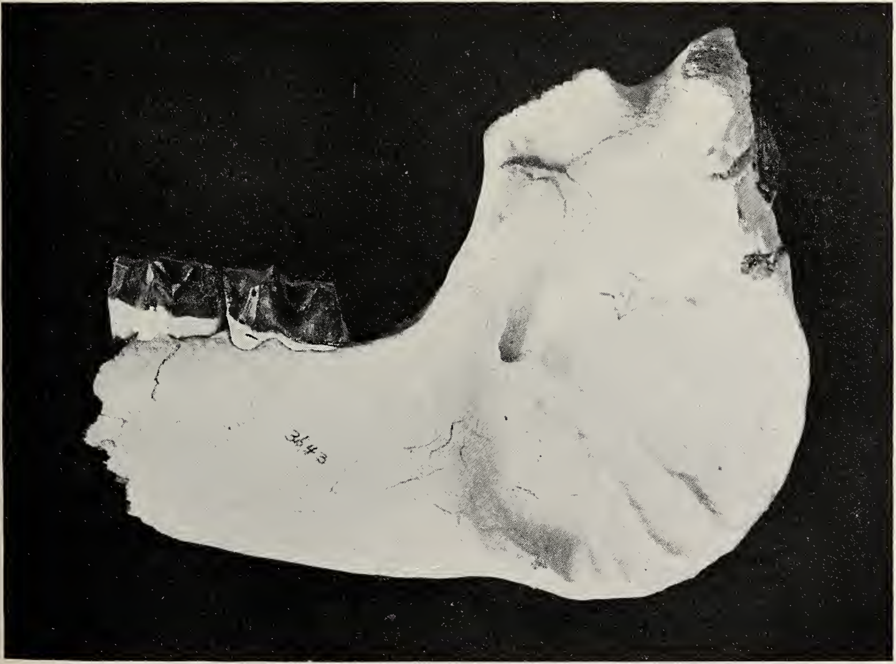
FOSSILS OF THE LAND PEBBLE PHOSPHATE DEPOSITS.

RHINOCEROSES.

Fig. 38.—Tip of the jaw of rhinoceros from the Amalgamated Phosphate Company at Brewster. Approximately one-half natural size. Fla. Geol. Surv. collection No. 3637. Length of symphysis in the center line 12 cm; width of jaw at the constriction 7.5 cm; space from incisor to premolar 60 mm; width across the jaw at the incisors 85 mm. Note the pronounced notch at the front of the jaw.

Fig. 39.—Base of the lower jaw of the rhinoceros from pit of the Amalgamated Phosphate Company at Brewster. Approximately one-third natural size. Fla. Geol. Surv. collection No. 3643. Crown of second molar 53 mm; third molar 53 mm.




3643

FOSSILS FROM THE RIVER PEBBLE AND OTHER PLEISTOCENE DEPOSITS AND FROM THE LAND PEBBLE PHOSPHATE DEPOSITS.

HORSES.

Fig. 40.—*Equus,* first or second right upper molar. Dredged from the Schilmann & Bene river mine on the Withlacoochee River. Fla. Geol. Surv. collection No. 1444. Twice natural size. Width of the grinding surface of the tooth, 15 mm.

Fig. 41.—*Equus,* second left lower premolar. From Vero. Fla. Geol. Surv. collection No. 1798. Slightly less than twice natural size. The grinding surface of the tooth measures 24 by 25 mm.

Fig. 42.—*Equus,* first left upper molar. From Vero. Fla. Geol. Surv. collection No. 1800. Slightly enlarged. Grinding surface of the tooth measures 30 by 28 mm.

Fig. 43.—*Equus,* left lower molar or premolar. From Vero. Fla. Geol. Surv. collection No. 1752. Enlarged times 1½. Grinding surface of the tooth 28 by 15 mm.

Fig. 44.—*Hipparion.* From pit of Prairie Pebble Phosphate Company, Mulberry. Fla. Geol. Surv. collection No. 4557. Enlarged. Grinding surface of the tooth measures 19 by 16 mm. Specimen contributed by the Cason Brothers, Mulberry, Florida.

The horses found in the land pebble phosphate deposits (Bone Valley formation) belong to the genus *Hipparion.* In the river pebble deposits the teeth of both *Hipparion* and *Equus* are frequently found. It is not probable, however, that these horses were contemporaneous in Florida, the *Hipparion* teeth having with little doubt been washed into the river pebble deposits from an older formation.

FOSSILS FROM THE RIVER PEBBLE PHOSPHATE DEPOSITS.

MASTODON, ELEPHANT AND HORSE.

Fig. 45.—*Mammut americanum* (the American mastodon). Unworn molar tooth from Alafia River. Approximately one-half natural size. Collection of S. A. Robinson. Length of tooth 18 cm; greatest width 9 cm. The teeth of *M. americanum* are readily distinguished from those of the more primitive mastodons of the Bone Valley formation by the fact that the valleys across the teeth are open and unobstructed, while in the teeth of the mastodons from the Bone Valley formation the cross valleys are obstructed by buttresses.

Fig. 46.—The Columbian elephant. Side view of an elephant's tooth, probably *Elephas columbi* var. Approximately one-fifth natural size. Fla. Geol. Surv. collection No. 3743. From the Caloosahatchee River. Found in the sand and muck above the shell marl. Grinding surface of tooth 30 by 15 cm; 5½ plates per 100 mm.

Fig. 47.—*Equus.* A lower tooth from a very large horse. Found at White Beach. Collection of Mr. Joseph Willcox.

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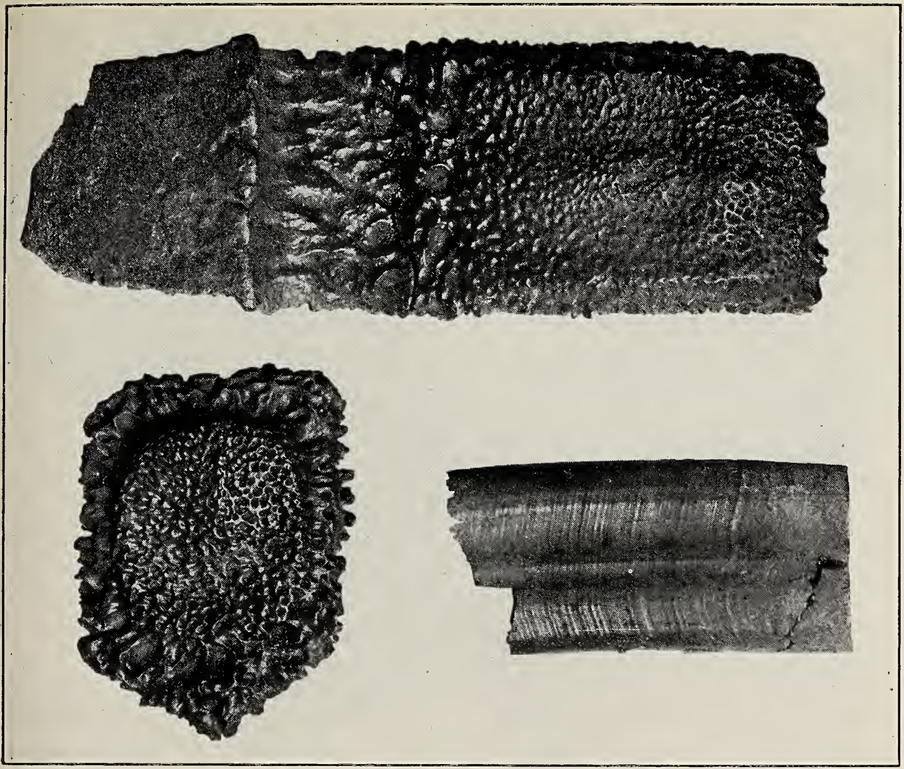
FOSSILS FROM THE RIVER PEBBLE PHOSPHATE DEPOSITS.

ARMADILLO AND CAPYBARA.

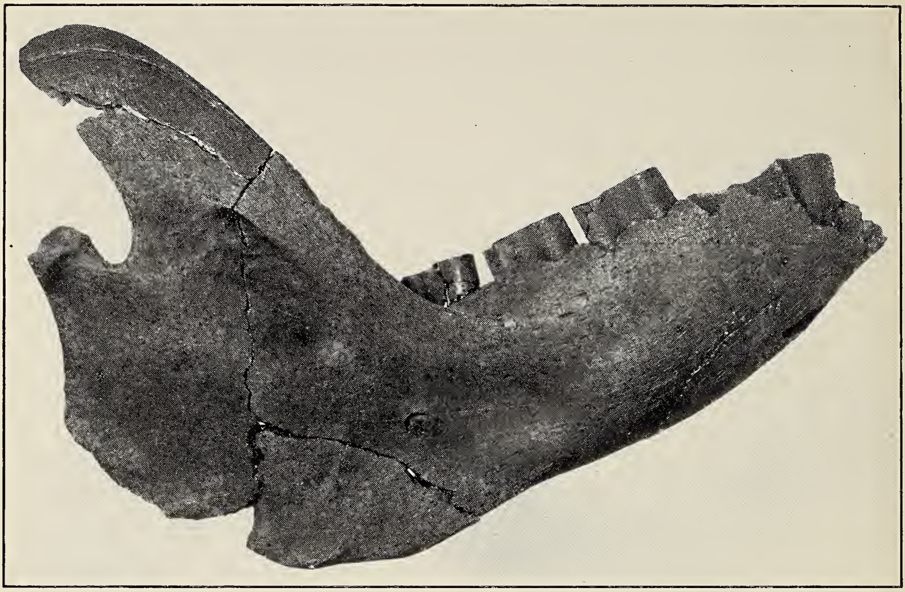
Fig. 48.—*Chlamytherium septentrionalis* (Leidy). At the top of the figure is seen a plate from the movable band, exterior view; below at the left, one of the dermal scutes, showing the coarse and rather deep sculpturing that characterizes most of the scutes of this species; at the right is seen the fourth tooth, counting from the back, of the right lower jaw, viewed from the inner side, showing the two faint furrows and the wavy cross lines of the tooth. Fla. Geol. Surv. collection. All natural size. From Vero.

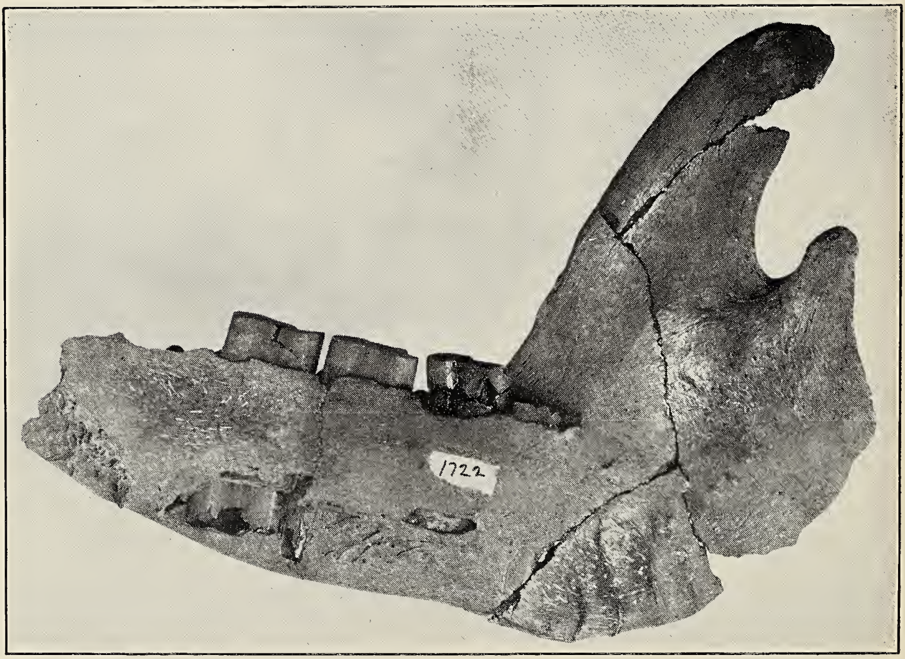
Fig. 49.—*Chlamytherium septentrionalis* (Leidy). The horizontal ramus of the right jaw viewed from above, showing the molariform teeth. Approximately four-fifths natural size. The tooth shown in fig. 48 is from this specimen. Fla. Geol. Surv. collection No. 1722. The specimens illustrated are from Pleistocene deposits at Vero, Florida. The same species, however, is found in the river pebble phosphate deposits on Peace Creek.

Fig. 50.—Molar teeth of a capybara-like rodent. Collection of S. A. Robinson. These teeth, which apparently represent an undescribed species, indicate a rodent similar to, but larger than the modern capybara of South America. In size this species approximates the giant capybara, *Hydrochoerus giganteus* Lund. The presence of this species in Florida is of interest since it indicates the existence of another of the South American animals in Florida during Pleistocene time.



ARMADILLO.





Figs. 51 and 52.—*Chlamytherium septentrionalis* (Leidy). Right lower jaw view from the outer and inner sides. One-half natural size. Fla. Geol. Surv. collection No. 1722. The canal, the location of which is seen below the specimen number, is apparently a character of generic, or more than generic value, as it is observed not only on this species but also on *C. humboldtii;* and *C. paranense.*

NATURAL RESOURCES SURVEY OF AN AREA IN CENTRAL FLORIDA.

INCLUDING A PART OF MARION, LEVY, CITRUS AND SUMTER COUNTIES.

BY E. H. SELLARDS, ROLAND M. HARPER, CHARLES N. MOONEY, W. J. LATIMER, HERMAN GUNTER AND EMIL GUNTER.

It is with regret that the Survey records the death of Mr. Emil Gunter, one of the co-authors of this report. Mr. Gunter, whose unfortunate death occurred at the early age of 31, was trained as an electrical engineer, and had his health permitted, would certainly have advanced rapidly in his profession. He was a painstaking and careful investigator and his work thoroughly reliable. He died at New Orleans, where he had gone for medical attention, on August 15, 1914.

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GEOLOGY AND MINERAL RESOURCES.

E. H. SELLARDS.

INTRODUCTION.

The following paper contains a description of the natural resources of a part of Central Florida. For the area under consideration the report includes an account of (1) the geology, (2) the mineral resources, (3) the native vegetation and (4) the soils. The data on which the paper is based have been obtained to a considerable extent in co-operation with the United States Geological Survey and the United States Bureau of Soils. Co-operative work with the United States Geological Survey in the study of the geology of the State was carried on actively during 1907 and 1908 and to some extent since that time. Co-operation with the United States Bureau of Soils in this area was carried on during the winter of 1911 and 1912, at which time the detailed soil survey of the area was made. At this time were secured also the data from which was made the map showing the distribution of the prevailing types of native vegetation. The data on which are based the plant lists and the description of the vegetation types were obtained for the Florida Survey during 1908-1909 and 1914-1915 by R. M. Harper.

THE AREA TREATED.

The section of the State treated in this report, the location of which is indicated on the accompanying sketch map, embraces parts of Marion, Levy, Citrus and Sumter Counties, including one-half degree of latitude (28° 45′ to 29° 15′), and one-half degree of longitude (82° to 82° 30′). The total area included is thus about 1,002 square miles. The selection of this section of the State for the present report was determined by the fact that topographic maps of the area had previously been made by the United States Geological Survey, thus facilitating field work. From these maps is taken the topography shown on the soil map, which accompanies this report.

CHEMICAL ANALYSES OF THE SOILS.

Chemical analyses of five samples of soil from the Ocala area are available and are included here for convenience of reference.

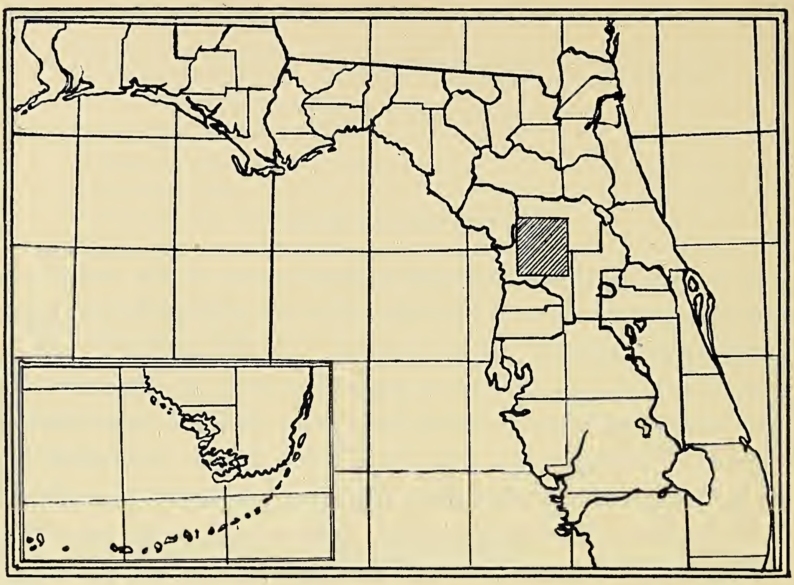

Fig. 53.—Sketch map showing the location of the Ocala area in Florida.

They are all from the hammock belt and therefore do not represent the average of the area. The first is of a sample collected by Dr. Eugene A. Smith in the summer of 1880, and analyzed under his direction at the University of Alabama by John B. Durrett, by the acid digestion method.* The other samples were collected by R. M. Harper in the spring of 1915, and analyzed by L. Heimburger, Assistant State Chemist, by the A. O. A. C. methods for fertilizers.† This method is believed to extract less potash than the acid digestion method, but the results for the other constituents can probably be safely compared with those obtained by the older and slower method.

Nitrogen is included in the volatile matter, and was not determined separately in the older analysis. Soda, magnesia, sulphur, manganese and soluble silica were not tested for, and iron and alumina were not separated by Mr. Heimberger, for their determination would have taken more time than their importance seemed to warrant.

The samples are as follows:

1. Dark gray high hammock soil, 10 inches deep, from one mile south of Ocala. Vegetation live, white and water oaks, magnolia, hickory, (red?) bay, sweet and sour gum.

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*Results copied from Tenth Census U. S., 6:204, 214, 1884.

†For a more explicit statement of the methods used see 6th Annual Report Fla. Geol. Surv., p. 397.

2. Red oak woods about 1½ miles E. S. E. of Ocala, 9 inches deep, taken at a place where the trees were all deciduous (figure 65).

3. Sandy hammock about six miles south of Ocala ("Leon sand"), 8 inches deep. Vegetation nearly all evergreen (figure 66).

4. Somewhat calcareous hammock about one mile southeast of Ocala, 8 inches deep. Vegetation about like that of No. 1 (figure 67).

5. Very calcareous high hammock about 2½ miles south of Ocala. A black loam with many fragments of soft white limestone, taken to a depth of 6 inches. Trees in the immediate vicinity nearly all deciduous, including *Quercus Schneckii, Acer Floridanum,* etc.

5a. Separate analysis of some of the rock from this sample.

ANALYSES.

	1	2	3	4	5	5a
Water (H_2O)	3.583	1.05	.09	.16	3.90	.45
Volatile matter		4.09	1.20	1.62	21.63	
Nitrogen (N)		.214	.180	.177	.591	
Potash (K_2O)	.112	.051	.021	.029	.119	
Soda (Na_2O)	.035					
Lime (CaO)	.185	3.13	.06	.11	7.32	41.40*
Magnesia (MgO)	.033					
Phosphoric acid (P_2O_5)	.110	5.35	.074	.328	2.14	1.02
Sulphuric acid (SO_3)	.054					
Brown oxide of manganese (Mn_3O_4)	.027					
Peroxide of iron (Fe_2O_3)	2.048	5.68				
Alumina (Al_2O_3)	2.494		.415	.81	4.26	
Soluble silica	1.380					
Insoluble matter	90.585	81.05	96.20	97.39	59.88	22.59
Total (excluding separate nitrogen)	100.646	100.401	98.060	100.447	99.249	

*Equivalent to 73.93 per cent calcium carbonate.

MECHANICAL ANALYSES OF THE SOILS.

The following mechanical analyses of soils from the Ocala area (all from the hammock belt) have been extracted from Bulletin 13 of the Division of Soils of the U. S. Department of Agriculture. (A preliminary report on the soils of Florida, by Milton Whitney, 1898). The localities and depth of the samples are as follows:

1. Light hammock near Ocala. Depth 0-9 inches.
2. Subsoil of same. 9-24 inches.
3. Lower subsoil of same. 24-36 inches.

4. Light hammock ½ mile south of Ocala. Depth 0-12 inches.
5. Subsoil of same. 12-30 inches.
6. Rich heavy hammock near Ocala. Depth 0-12 inches.
7. Rich heavy hammock 2½ miles south of Ocala. Depth 0-12 inches.

ANALYSES.

	Light hammock					Rich heavy hammock	
	Near Ocala			½ mile S.		Near Ocala	2½ miles S.
Gravel (2-1mm.)	Tr.	Tr.	Tr.	Tr.	0.28	0.27	1.58
Coarse sand (1-.5mm.)	1.59	1.80	1.45	3.07	3.30	2.16	2.62
Medium sand (.5-.25mm.)	15.63	18.25	19.63	21.44	22.29	17.01	13.08
Fine sand (.25-.1mm.)	62.87	65.37	62.40	53.54	55.29	40.94	46.32
Very fine sand (.1-.05mm.)	15.70	10.07	11.65	13.30	10.64	20.26	19.83
Silt (.05-.01mm.)	1.25	1.20	1.80	2.68	2.62	5.61	3.38
Fine silt (.01-.005mm.)	0.48	0.55	0.62	1.33	1.64	2.23	1.50
Clay (.005-.0001mm.)	0.61	1.39	1.26	2.39	3.06	5.55	6.86
Organic matter	1.16	0.75	0.65	1.36	0.92	4.94	2.61
Moisture, air-dry	0.35	0.22	0.30	0.49	0.32	1.61	1.39
Total	99.64	99.60	99.76	99.60	100.36	100.58	99.17

The following statistical information on this area has been compiled by Dr. R. M. Harper:

Although the area treated does not include the whole of any one county, and it is therefore impossible to estimate its population accurately, some statistics of the density and composition of the population of Marion County will probably be typical enough for the whole area. Nearly half the area is in that county, which includes within its borders considerable areas of rich farm land, timber land, phosphate mines and unproductive scrub. (Its area has not been changed since 1880, when one of the most complete censuses was taken, but Citrus County did not exist then, and Sumter was considerably larger than at present, so that comparisons between 1880 and 1910 cannot be made for those counties.)

The density of population of Marion County was about five inhabitants per square mile in 1860, 6.3 in 1870, 7.8 in 1880, 12.5 in 1890, 14.7 in 1900, and 16.4 in 1910. The percentage of whites has oscillated between 35 and 45 per cent at the last four censuses. The white population nearly doubled between 1880 and 1890, the decade in which phosphate was discovered, and increased less than 1 per cent between 1890 and 1900, the decade of two severe freezes which almost destroyed the citrus fruit industry in this latitude.

Of the total population of Marion County in 1880, 61.8 per cent were born in Florida, 21.5 per cent in South Carolina, 7.2 per cent in Georgia, 2.6 per cent in Alabama, 1.4 per cent in North Carolina, 0.8 per cent in Virginia, 4 per cent in other states, and 0.7 per cent in foreign countries. (The great preponderance of South Carolinians over Georgians is interesting, but not easy to explain.) No similar statistics are given in later censuses for areas smaller than states, but it is reasonable to assume that the character of the immigration has not changed greatly since, and that somewhat similar proportions hold in the other counties.

Of the total area of Marion County, 5 per cent was classed as improved land by the census of 1880, and 8.3 per cent by that of 1910. (The increase has probably been greater in the other counties in the area.) In 1880 there were 1434 farms in the county, the value of whose product for the previous year was $508,338. The expenditure for fertilizer was only a little over 2 cents per acre of improved land, 9 cents per inhabitant, or 74 cents per square mile of total area. In 1910 there were 2153 farms, with a product of $1,835,212 (not counting live stock, poultry, etc.), and an expenditure for fertilizer of $1.68 per acre, $5.53 per inhabitant, or $88 per square mile. (At the same time fertilizer was used in Citrus County at the rate of 65 cents per acre or $6.18 per square mile, and in Sumter $3.31 per acre or $128 per square mile, if the census figures are accurate.) The enormous increase in the use of fertilizer is of course due largely to the extension of cultivation from the rich hammock lands to the poorer pine lands.

The leading crops in Marion County in 1911-12 (just about the time the soil survey was made), in order of value, according to the 12th Biennial Report of the State Department of Agriculture, were as follows: (Cantaloupes, oranges, watermelons, sea-island cotton, velvet beans, corn, tomatoes, beans, lettuce, grapefruit, peanuts, sweet potatoes, cabbage, upland cotton, field peas (including hay thereof), sugar cane (syrup), cucumbers, egg-plants, (grass) hay, squashes, onions, oats, pepper, pears, peaches, cassava and rye. Of these the first made up about 18 per cent of the total and the last about 0.14 per cent.

With regard to the use of plant names as found in the soil report, he notes also that saw-grass is a sedge (*Cladium*), and broom sedge is a grass (*Andropogon*). Sword grass may be a species of *Iris*. Cypress is not a hard wood tree.

GEOLOGY.

The geologic structure in central Florida is not complicated. the formations being of sedimentary, or sedimentary-organic origin, and but little disturbed from their original horizontal position. Over a considerable part of the area described in this report the Ocala limestone is the country rock.* This formation, the type locality of which is at Ocala, has been fully described and its general distribution mapped in the preceding reports of the Survey. The formation consists chiefly of a light-colored, granular, highly fossiliferous limestone. As a rule the rock when taken from the pit is soft, although it hardens upon exposure. Locally, however, the limestone has become compact and more or less crystalized, it also contains masses and layers of flint.

Overlying the Ocala limestone is found remnants of upper Oligocene deposits, particularly of the Alum Bluff formation which includes calcareous and phosphatic sands and sandstone alternating with sandy clays and beds of fuller's earth. These later deposits, although formerly extending over the whole area, are now found only on the uplands or capping the hills, having been largely removed elsewhere by erosion.

The residue of these formations was reaccumulated, probably during Pliocene time, to form the Alachua formation, in which is found the hard rock phosphate deposits. The formation of these deposits and the processes by which the hard rock phosphates accumulated have been fully described in the preceding reports of the State Survey. Local Pleistocene or later deposits are found in this part of the State in caves and in crevices in the rock as well as in lake basins and in sinks.

Since becoming dry land this area has been very profoundly modified by surface and underground erosion. Not only has the surface configuration been modified, but new drainage conditions have been established which in turn affect both the soils and the vegetation.

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*The general term Vicksburg Limestone has usually been applied to this formation, and is so used in the Soil Survey report on this area. Recent investigations, however, seem to indicate that the Ocala Limestone is to be recognized as a formation distinct from the Vicksburg and referred to the upper Eocene. See report on Pebble Phosphates (this volume).

MINERAL RESOURCES.

The mineral resources of the Ocala area include in addition to springs and underground waters, phosphate rock, lime, limestone, and marl, fuller's earth and other clays.

SPRINGS AND WATER SUPPLIES.

The water supply in this area is drawn chiefly from the Alum Bluff sands and clays and from the Ocala limestone. The water from sands and clays, although not obtained in such large supplies as from the limestone, yet has the advantage of being soft and relatively free from mineral matter in solution. The depth that it is necessary to drill or to sink a well for water varies in different localities. On the hills and the uplands where the Alum Bluff formation persists a supply of water sufficient for household and family use can usually be obtained at a very moderate depth. In the lowlands, on the other hand, it is frequently necessary to drill into the limestones. For deep wells from which a large supply of water is to be drawn it is usually necessary to continue the drill hole into the limestone until either a cavity or a porous layer is reached. Representative wells of this area are listed in the following table.

SPRINGS.

Some exceptionally large springs, as well as many small ones, are found in this part of the State. Silver Springs at Ocala probably has the largest flow of any spring in the world, namely, 368,913 gallons per minute. Freight and passenger boats, following the stream, enter and dock at the spring, affording one of the few cases of a stream navigable to its very head. Blue Springs at Juliette is also a large spring, flowing about 346,166 gallons per minute. These springs flow from the Ocala limestone, and the water, as is usually true of limestone springs, is wonderfully clear and transparent, small objects being visible on the bottom of the spring at a depth of 40 feet or more.

With regard to this spring Professor John LeConte who visited the spring in 1859 wrote as follows:*

> "The most remarkable and interesting phenomenon presented by this spring is the truly extraordinary transparency of the water; in this respect surpassing

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*Amer. Journ. Sci., Vol. XXXI, p. 3, 1861.

anything which can be imagined. All of the intrinsic beauties which invest it, as well as the wonderful optical properties which popular reports have ascribed to its waters, are directly or indirectly referable to their almost perfectly diaphaneity. On a clear and calm day, after the sun has obtained sufficient altitude, the view from the side of a small boat floating on the surface of the water near the center of the head-spring, is beautiful beyond description, and well calculated to produce a powerful impression upon the imagination. Every feature and configuration of the bottom of this gigantic basin is as distinctly visible as if the water was removed, and atmosphere substituted in its place!

* * * * * * * *

"My observations were made about noon, on the 17th and again on the 20th of December, 1859. The sunlight illuminated the sides and bottom of this remarkable pool as brilliantly as if nothing obstructed the light. The shadows of our little boat, of our overhanging heads and hats, of projecting crags and logs, of the surrounding forest, and of the vegetation at the bottom, were distinctly and sharply defined; while the constant waving of the slender and delicate moss-like algae, by means of the currents created by the boiling up of the water, and the swimming of numerous fish above this miniature subaqueous forest, imparted a living reality to the scene which can never be forgotten. And if we add to this picture, already sufficiently striking, that objects beneath the surface of the water, when viewed obliquely, were fringed with the prismatic hues, we shall cease to be surprised at the mysterious phenomena with which vivid imaginations have invested this enchanting spring, as well as the inaccuracies which have been perpetuated in relation to the wonderful properties of its waters. On a bright day, the beholder seems to be looking down from some lofty airy point on a truly fairy scene in the immense basin beneath him, a scene whose beauty and magical effect is vastly enhanced by the chromatic tints with which it is invested."

The prismatic hues seen in this and other clear water springs of Florida Professor LeConte believed to be due to the refraction of light passing through the water. He found that white objects on a dark background when immersed in the water are fringed with blue at the top and orange and red at the bottom, while the color of the fringing is reversed for dark objects on a white background.

ANALYSES OF WELL AND SPRING WATER.

Silver Springs, Marion Co. Analysis made by the U. S. Geological Survey. 1907.

Ingredients.	Parts per million.
Calcium	73.
Magnesium	9.2
Sodium and potassium	9.8
Iron and alumina	trace
Carbonate	0.0
Bicarbonate	219.

TABLE OF WELLS

Nearest town or P. O.	Direction and Distance.	Owner of Well.	Driller	Depth in feet.	Diameter in Inches.	Casing in feet	Elevation above sea.	Head from surface.	Use of Well.	Mineral character of water.
Belleview	1 mi. N.	McGeehee & Mayo	E. L. Freyermeuth	80	2				Turpentine still	Hard
Coleman	½ mi. N.	Coleman Cypress Co.		225	6	225			General	Hard
Dunnellon	Near	City	J. D. Allen	155	6	90	50	-20	City supply	Hard
Dunnellon	Near	Atlantic Coast Line	J. D. Allen	300	8	100	50	-20	Locomotives	Hard
Dunnellon	1¼ mi. N.	Dunnellon Phos. Co.	McIver & MacKay	175	12		60	-27	Phosphate mining	Hard
Dunnellon	1¼ mi. N.	Dunnellon Phos. Co.	McIver & MacKay	235	6		60	-27	Phosphate mining	Hard
Felicia		Dunnellon Phos. Co.		380	8			-60	Washing phosphate	Hard
Hernando	½ mi. S.	Dunnellon Phos. Co.	McIver & MacKay	152	12	70	70	-50	Phosphate mining	Hard
Hernando	1 mi. N. W.	Dutton Phos. Co.	J. O. Edson	142	10		65	-35	Phosphate mining	Hard sulphur
Holder	1½ mi. N. E.	Buttgenbach Phos. Co.	J. O. Edson	100	12	42		-45	Phosphate mining	Hard
Holder	2 mi. E.	Buttgenbach Phos. Co.	J. O. Edson	145	12	72		-54	Phosphate mining	Hard
Inverness	1¼ mi. W.	Mutual Mining Co.	J. O. Edson	127	10	44	75	-47	Phosphate mining	Hard
Inverness	1¼ mi. W.	Mutual Mining Co.	J. O. Edson	124	10	40	75	-47	Phosphate mining	Sulphur
Inverness	Near	C. S. Bohanon	J. Robertson	66	2	66	70		Hotel use	Hard
Juliette	2½ mi. N. W.	Dutton Phos. Co.	Hughes Spec. Well Drill. Co.	796	14	280	90	-54	Phosphate mining	Hard
Juliette	2½ mi. N. W.	Dutton Phos. Co.	J. D. Allen	310	10	50	90	-54	Phosphate mining	Hard
Lecanto	1 mi. N.	W. A. Allen	Owner	97	2	97		-89	Household	Hard
Lecanto	2 mi. N. W.	P. L. Allen	E. H. McIlvane	125	2			-105	General	Hard
Leroy	Near	Public	E. L. Freyermeuth	46	2		85	-42	Public	Hard
Leroy	1 mi. E.	Clark, Ray, Johnson Co.	Sam. Hunt	140	3		100	-70	Turpentine still	Hard
Martel	Near	Martel Lumber Co.	McIver & MacKay	72	6	72		-32	Sawmill	Hard
Ocala	4 blks. S. E.	Ocala Water Co.		190	12			-72	City supply	Hard
Ocala	4 blks. S. E.	Ocala Water Co.	E. F. Joyce	1250	8		100	-70	City supply	Hard sulphur
Ocala	¼ mi. N.	Ocala Ice & Pack. Co.	W. F. Hamilton	172		172	65	-21	Ice manufacture	Hard
Oxford	¼ mi. N. W.	H. O. Collier	E. L. Freyermeuth	86	2	80	100	-50	General	Hard
Oxford	Near	J. F. Lavine	E. L. Freyermeuth	76	2	60	100	-52	General	Hard
Oxford	1 mi. S.	J. S. Reese	E. L. Freyermeuth	92	4		77	-31¼	Irrigation	Hard
Oxford	Near	Sunset Crate & Lbr. Co.	W. F. Hamilton	74	4		100	-55	Gen. mill purpose	Hard
Rock Springs	Near	Meffert & Maynard	E. L. Freyermeuth	78	2½	78	70	-30	Sawmill and still	Hard
Silver Spgs.	¼ mi. E.	E. P. W. Rentz Lbr. Co.	H. F. Lloyd	507	2		45	-5	Sawmill purposes	Hard sulphur

PHOSPHATE.

The phosphate deposits constitute one of the very important mineral resources of the Ocala area. These beds, which are fully described in a preceding report of the State Survey,* reach their maximum thickness in the western part of Marion and the eastern part of Citrus Counties. The phosphate from this formation is known on the market as "hard rock," and is of such purity as to permit a guarantee of 77 to 80 per cent tri-calcium phosphate.

LIME, LIMESTONE AND MARLS.

Limestone is found in great abundance in this section and is utilized for various purposes. The center of the lime manufacture industry of Florida is in and near Ocala, the Ocala limestone being used for this purpose. Ground limestone for agricultural purposes is also produced by these lime plants. This is used to sweeten the soils, and by so doing to increase their productivity. The Ocala limestone is also extensively used for road purposes, as the soft rock, or marl phase of the formation may be applied to roads direct, being then compacted by a roller or by travel. In places the limestone is hard and when crushed makes an excellent concrete material. Siliceous boulders are also found in this formation, some of which, particularly in the phosphate mines where they are thrown out in the process of mining, are crushed for concrete, and other purposes.

Analysis of the Ocala limestone, Ocala. Analysis by the State Chemist of Florida for the State Geological Survey.

Calcium oxide, 55.52%, equivalent to calcium carbonate	99.15%
Iron and aluminum oxides	.35%
Insoluble matter, sand, clay, etc.	.30%

CLAYS.

Although not yet utilized, fuller's earth clays are known from the vicinity of Fairfield in Marion County. These beds lie in the Alum Bluff formation and with little doubt extend into the area covered by this report. Fuller's earth has been found also at Belleview in Marion County.

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*Fifth Annual Report, Fla. Geol. Surv. pp. 23-80, 1913.

THE NATIVE VEGETATION.

In connection with the soil survey of this area there was presented a favorable opportunity for preserving a record of the distribution of the native vegetation. The permanent preservation of this data has seemed the more desirable from the fact that as the land is cleared for cultivation the record of the distribution of the vegetation types or plant groups is obliterated. Moreover, that there is an important relation between the soils and the native vegetation is a fact that is well recognized. and indeed the character of the vegetation is much used by the average farmer in selecting land for cultivation. It is probably true also that as future soil studies progress this relationship will be the more clearly developed and will become more fully understood. For this reason it is believed that the vegetation map accompanying this report will prove of much value in future studies of the soils of this area.

The data on which the vegetation map is based have been collected by the authors of the soil report, namely Herman and Emil Gunter of the Florida Geological Survey and Charles N. Mooney and W. J. Latimer of the United States Department of Agriculture. The identification of the plants, which was necessary in order to properly characterize the plant groups or vegetation types, has been made at various times during 1908, 1909, 1910, 1914 and 1915, by Dr. R. M. Harper. In addition to merely listing the plants Dr. Harper has made use of original methods of quantitative studies by which the relative abundance of individuals of the different species is indicated. The proportion of evergreen and deciduous plants is also indicated, bold faced type being used for the evergreen species. The plant lists thus arranged, express at a glance the relative components of the several plant groups. The vegetation types described by Dr. Harper agree in the main with those mapped by Messrs. Mooney, Latimer, Gunter and Gunter. Minor differences, however, will be noted.

In designating the several plant groups it has seemed best to use in this report terms already largely in use indicating the predominating timber growth, and in so far as possible the topography of the land and character of the soil. In this way it has not been found necessary to introduce terms other than those already in use and generally understood.

EXPLANATION OF THE VEGETATION MAP.

By way of explanation of the map it may be said that the chief timber growth of this area is the long-leaf pine, *Pinus palustris,* and the term "Pine lands," as commonly used in the section, refers to lands on which this species of pine predominates. Several other pines are present, but they are in no case so widespread, nor do they dominate the timber growth in the section in which they occur as does the long-leaf pine. The pine lands in turn are classed on the basis of topographic, drainage and soil conditions as "rolling pine lands" and "flatwoods." The rolling pine lands include the more or less undulating well-drained country over which the principal timber growth is the long-leaf pine. The top soil to the depth of a few inches is prevailingly gray owing to the presence of organic matter mixed with light-colored sand. A few inches beneath the surface the soil becomes ochre yellow in color. At this depth also it retains sufficient clay particles or silt to give it a loamy texture. The soils of this type of country are placed chiefly in the Norfolk series. Three grades of high or rolling pine lands are shown on the map as follows: Open pine, pine with black jack undergrowth, and pine with turkey oak undergrowth.

The flatwoods include the level and hence poorly drained pine lands. Two distinct types of flatwoods vegetation are recognized, namely, the palmetto (including gallberry) flatwoods, and open flatwoods. In the palmetto flatwoods the chief timber growth is the long-leaf pine and related species. The undergrowth includes an abundance of saw palmetto, and locally of gallberry. The land is poorly drained, the water table being as a rule near the ground surface. The top soil is usually light-colored, although in places it contains sufficient organic matter to give it a dark color. At a depth of 12 to 24 inches the light-colored sand, practically without exception, passes abruptly into a dark chocolate sand stratum of several inches thickness known as hardpan, which grades below into light-colored sand. The open flatwoods differ from the palmetto flatwoods in that there is almost no undergrowth other than the heavy mat of wire-grass. This land is less well drained than is the palmetto flatwoods, and the soil contains for this reason a considerable admixture of organic matter. Hardpan is rarely, if ever, found underlying the open flatwoods. In the area covered by this report the open flatwoods find but a limited development, being largely confined to a small section in the extreme northeastern part of the area. Practically all open flatwoods soils must be drained before they are available for agriculture. After drainage they may and frequently do constitute one of the highly productive soil types.

The term "Hammock," as commonly used in contrast to pine lands, is applied to vegetation in which the timber growth is sufficiently dense to result in the accumulation of leaf mold on the surface. Frequently the timber growth of the hammocks is deciduous or largely so. This, however, is by no means essential, since the predominating growth may be evergreen. Again hardwoods are usually a conspicuous element in hammocks, and yet pines may be numerous. The soil and drainage conditions in the hammocks are likewise variable, giving rise to a wide variation of vegetation types or plant groups which are more or less definitely correlated with the conditions of the soils, the geologic structure, topography and drainage conditions.

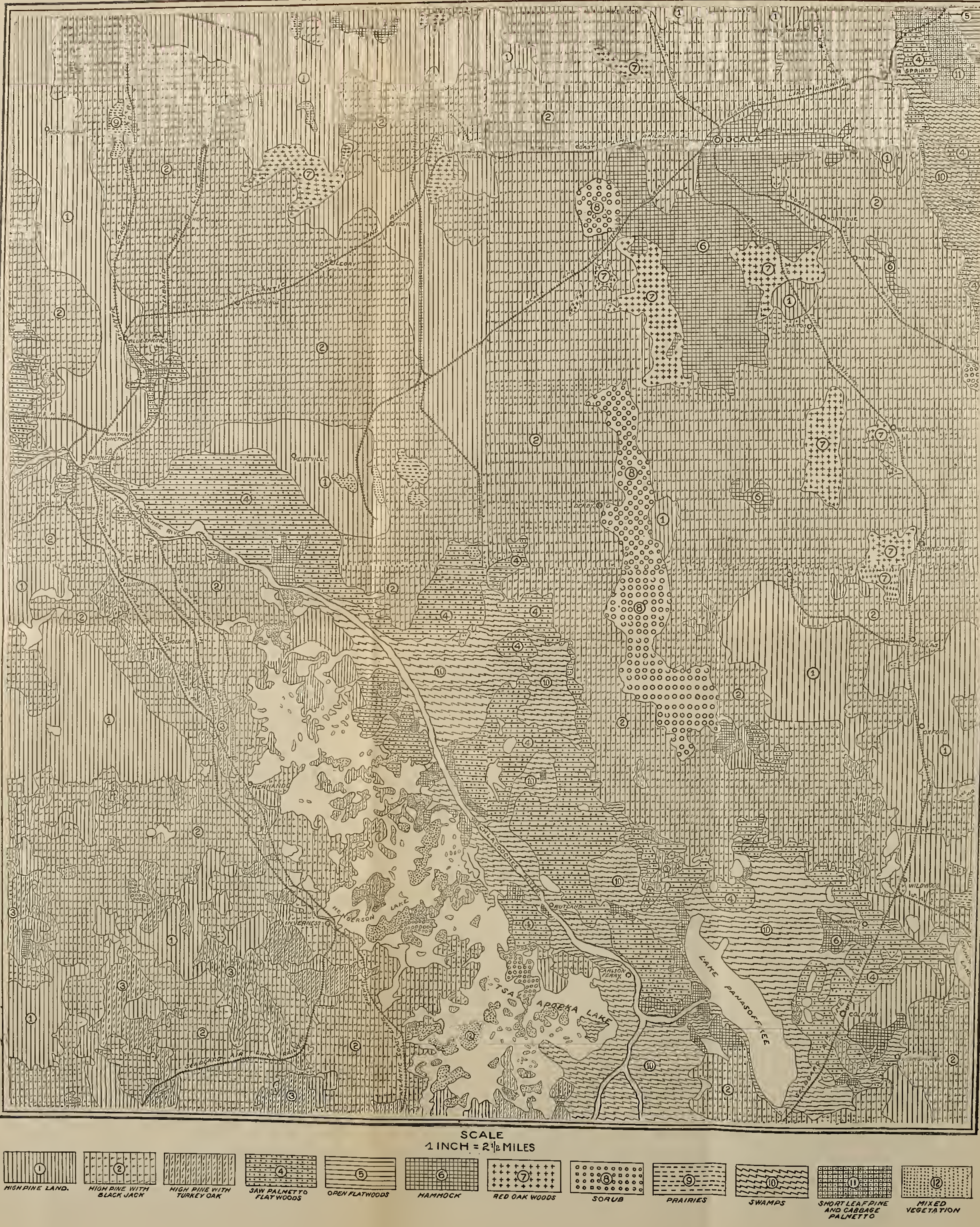
In addition to the pine and hammock lands are the prairie lands, and some other types of relatively slight extent, as shown on the vegetation map, and described under vegetation types.

RELATIONSHIP BETWEEN THE GEOLOGY, VEGETATION AND SOILS.

That there is a definite relationship between the geology, vegetation and the soils is apparent. The main features of the geology have been sketched, and it is shown that the limestones now exposed at the surface were formerly overlaid by clay and sandy calcareous strata of which remnants still remain on the uplands, while over the whole is found the mantle of residual material which forms the soils.

The stages in the development of some of the important soil types may be readily followed and correlated with the physiographic development of the region. The clay hammock lands are found chiefly where the Alum Bluff formation yet remains, the soil being derived from the clayey and sandy strata of that formation. The calcareous hammock lands are found where this formation is sufficiently broken up to permit subterranean drainage. The rolling pine lands in this area represent for the most part country in which the disintegration of the Alum Bluff formation is complete, the soil having become an ochre yellow sand with a slight mixture of silt or loam. A further stage of disintegration results in leaching out largely the soluble constituents of the soil. Under these conditions of excessive drainage the open long-leaf pine gives place to the scrub oak pine lands.

The data on which the accompanying vegetation map is based were secured by Herman Gunter and Emil Gunter of the Florida Geological Survey and C. N. Mooney and W. J. Latimer of the U. S. Bureau of Soils. The map is intended to represent as nearly as is practicable the distribution of the predominating types of the native timber growth of this area.

OCALA
BELLEVIEW
SUMMERFIELD
DERBY
DALLAS
OXFORD
WILDWOOD
COLEMAN
SANTOS
HAYES
DUNNELLON
HERNANDO
INVERNESS
RUTLAND
CARLSON FERRY
HENDERSON LAKE
TSALA APOPKA LAKE
LAKE PANASOFFKEE
WITHLACOOCHEE RIVER
ATLANTIC COAST LINE RAILWAY
SEABOARD AIR LINE RAILWAY
SCALE
1 INCH = 2½ MILES
① HIGH PINE LAND.
② HIGH PINE WITH BLACK JACK
③ HIGH PINE WITH TURKEY OAK
④ SAW PALMETTO FLAT WOODS
⑤ OPEN FLATWOODS
⑥ HAMMOCK
⑦ RED OAK WOODS
⑧ SCRUB
⑨ PRAIRIES
⑩ SWAMPS
⑪ SHORT LEAF PINE AND CABBAGE PALMETTO
⑫ MIXED VEGETATION

VEGETATION TYPES.

ROLAND M. HARPER.

INTRODUCTION.

The area covered by this report includes parts of five of the geographical divisions described by the writer in the 3d and 6th Annual Reports. A narrow strip extending the whole length of the eastern edge of the map is regarded as belonging to the lake region, though some of it is not very typical. The high hammocks near Ocala are an extension of the Middle Florida hammock belt. The high pine land in the central portion, covering over half the area, belongs to the lime-sink or hard-rock phosphate region. The level rocky country on both sides of the Withlacoochee River represents the Gulf hammock region, and the flatwoods west of Dunnellon, which are essentially non-calcareous, seem to be the southeastern corner of the Middle Florida flatwoods (which the writer formerly supposed terminated farther north). Each of these regions is characterized by a different aggregation of vegetation types.

The native vegetation can be divided into a dozen or more fairly distinct types, as shown on the vegetation map. Some of them are confined (in this area at least) to one of the regions just mentioned, while others are common to two or more of them. In such a small area as this the diversity of vegetation is due to soil more than anything else, for the climate does not vary enough to have any perceptible influence.*

The vegetation map does not correspond exactly with the soil map, however, for the distribution of plants is governed by other factors than soil and climate. One of these might be called the historical factor. A certain plant may be common in one part of the world and absent from another where conditions are favorable for it, simply because it has not had time or opportunity to reach the latter place since the conditions became favorable. A much more important factor in limited areas is fire. Two areas of the same kind of soil, one protected from fire by being surrounded by water or some other barrier and the other not, may have very different vegetation, as is exhibited in many places in the Ocala area, and will be discussed below.

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*Some statistics of climate are given in the chapter on soils. The most significant features of the climate here, as compared with other parts of the eastern United States, are the mild winters and wet summers. At Ocala the average temperature for January, the coldest month, is 57.4° F., though frost is frequent through the three winter months. Nearly 60% of the annual rainfall comes in the four warmest months, June to September, and over 70% in the six warmest months, May to October. Such a climate seems to affect the soil in such a way as to favor the growth of evergreens more than deciduous trees in most parts of the area, as will be pointed out below.

Most previous studies of vegetation have included lists of plants arranged in taxonomic or in alphabetical order (which is convenient for reference but has little significance), or worse still, merely in the order in which they happened to be observed or thought of, with little or no indication of relative abundance. But abundance is all-important, for naturally it is the most abundant species that give the vegetation its character. It would be possible for example for two forest areas to contain exactly the same species of trees, but in very different proportions, so as to give the forests quite different aspects and indicate very different soils.

In the plant lists below the species are first divided into trees, small trees or large shrubs, vines, shrubs and herbs, except where one or more of these classes is absent or where two of them are combined for some special reason; and the species in each class are arranged as nearly as possible in order of abundance.* The rarer species of flowering plants and ferns, and all the mosses, lichens, fungi, etc., are omitted, partly because of some uncertainty about their correct identification, and partly because the importance of a species in vegetation studies is believed to be directly proportional to its size and abundance. The rare species are indeed interesting to mere collectors, but their value as indicators of environmental conditions is negligible. As the field work on which these lists is based has been done mostly in spring and summer, it is quite likely that some herbs that bloom only in the fall have been overlooked; but this difficulty does not apply to the trees and shrubs.

On account of the limited amount of field work that has been done on some of these vegetation types, and for other reasons which will appear, the figures representing the relative abundance of each species are not published, though some conclusions drawn from them, which are not likely to be affected much by more thorough work which may be done hereafter, are given in their proper places.

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*For a discussion of methods of quantitative analysis of vegetation see 6th Annual Report, pp. 177-180.

For example, although the percentages for single species might not be very accurate, when those of all the species belonging to a certain family are consolidated, the errors are bound to counterbalance each other to a considerable extent. It is useful to remember that the figures showing the percentages of different species in a given area or region (if not too small) when arranged in order tend to form a geometrical progression, those near the head of the list always being farther apart than those near the foot. In other words, there are everywhere more rare species than abundant ones.

The separation of trees, shrubs, herbs, etc., has several advantages, one of which is that it is not practicable to compare the abundance of species differing greatly in size. The trees too are more reliable indicators of environmental conditions than the smaller plants are, because their roots penetrate a greater variety of soil and their branches reach higher into the air, and because owing to their longer life they have to withstand the climate of all seasons and of many different years. The occurrence of many herbs depends on the shade and humus furnished by the trees around them more than it does on the mineral soil underneath; and the cold of winter, when they are dead, makes little difference to them; but most of the trees have to have the right kind of soil in the beginning, and there is a certain minimum endurable temperature for each one.

This study is concerned only with native plants, and it seeks to reconstruct the primeval conditions as far as possible, disregarding the numerous introduced weeds that flourish in fields and lots, along roads and railroads, etc., as well as all cultivated crops.

DETAILS OF TREATMENT.

For each type of vegetation the more obvious characters of soil, topography and ground-water are first indicated, with references to the chapter on soils for more detailed information. Under the head of soil are included some desultory observations on the soil fauna, a very important matter which has been strangely neglected by most soil investigators. Allusion is made also to the frequency of fire, an environmental factor of great importance which has received very little consideration from botanists, especially those who do most of their research in laboratories (for fire does not lend itself well to experimental treatment). Although fire is a secondary factor, depending largely on the vegetation itself, there are many places where physiographic factors reduce its frequency to a minimum, and such places differ greatly in their vegetation from those where there is nothing to check the spread of fire. It would be hard to find an area of the same size which affords better opportunities for studying the effects of different frequencies of fire than this one does.

In the lists of plants both technical and common names are given when possible. The technical names correspond for the most part with those in Small's Flora of the Southeastern United States, though that encyclopedic work is not followed in any case where it is known to be incorrect or out of date. Nearly all the trees have common names, but some of the smaller plants of course are so inconspicuous or unimportant that they have never been named except by botanists. For many such plants alleged common names can indeed be found in botanical books, but they would mean no more to the average reader than the technical names do. The common names adopted here are *bona-fide* ones, known to be used in Florida by persons without botanical training; but in a few cases names used in other states, which may be familiar to some readers, are given in parentheses.

The technical names of evergreens are printed in heavy type, and in the case of semi-evergreens only the second half of the name is thus printed. This will help the reader to picture to himself the winter aspects of the vegetation, and the contrasts between different types. The significance of evergreens is more than merely ornamental, too, for it is pretty evident to an intelligent observer that, in the eastern United States at least, they are most abundant in the poorer soils, and vice versa. Within the area here treated the proportion of evergreen trees in different types of forest varies from less than 10% to over 90%; and those which have over 90% are rarely disturbed by the farmer.*

It is interesting to consider also the proportion in each vegetation type of plants belonging to certain well known and widely distributed families, such as the Ericaceae and allied families (heaths, huckleberries, etc)., Leguminosae (leguminous plants) and Gramineae (grasses). The Ericaceae are especially characteristic of sour soils, poor in lime or potash, or both, and the Leguminosae of upland soils pretty well supplied with mineral plant food but poor in humus (for they have a way of getting nitrogen from the air, without having it supplied by the soil). The latter are therefore scarce both in the poorest soils and in hammocks, and abundant in the high pine land, which is dry and practically devoid of humus.

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*For a discussion of the relation of evergreens to soils see 6th Annual Report, pp. 175-177 (footnote), 396.

Some notes on the general geographical distribution of the species and their economic properties are added in a few cases; and one or more photographic illustrations of nearly every vegetation type are given. The order in which the different vegetation types is taken up is necessarily somewhat arbitrary, for they do not form a linear sequence, but are interrelated in a complex manner. Generally speaking, however, the sparsest and most open vegetation is described first.

In order to facilitate comparisons between different vegetation types, after the name of each species is put the numbers of the other types in which it occurs in sufficient abundance to be listed. Thus the species which have the most numbers are most widespread in the area, and those which have none are confined to one vegetation type, or nearly so. Some conclusions based on these numbers are given at the end of this paper.

THE VEGETATION TYPES IN DETAIL.

1. (SHALLOW) LAKES, PONDS AND PRAIRIES.

(FIGURES 57-58.)

The lakes and ponds in this area (nearly all of which are in the southern half), except Lake Panasoffkee and possibly some of those on the eastern border, are all very shallow with nearly flat shores, and subject to considerable seasonal fluctuation, so that they are bordered by pretty wide areas sometimes inundated and sometimes exposed. In northern Florida and southern Georgia and Alabama such areas would ordinarily be wooded with cypress, black gum, and other water-loving trees, but in this area they are nearly destitute of woody plants, for some reason not yet apparent. Some of the smaller ponds dry up completely in spring, and are then known as prairies.

The soil of the lake margins and prairies in the Ocala area is a rather sterile sand, with a little peat mixed with it in places, and occasional small outcrops of more or less silicified limestone, which seems to have little effect on the vegetation. (The water may be a little calcareous, however.) Some of these areas are too small to show on the soil map at all, and some have been mapped as water and some as "Portsmouth sand" and "Portsmouth fine sand."

The best development of prairie vegetation in the area is found in and around Lake Tsala Apopka, a very irregular and ill-defined body of water which varies greatly in area in different seasons and in different years. The deeper and more permanent pools in this lake and elsewhere contain water-lilies and other strictly aquatic plants, and some of the small ponds which become nearly but not quite dry (mostly among the hammocks around Ocala) contain a few small trees and shrubs. The smallest prairies and pond-margins have vegetation similar to that around Lake Tsala Apopka. Although the vegetation of lakes is of course quite different from that of prairies, there are all gradations between, and all treeless areas permanently or periodically inundated are here combined.

The following list is based on observations made in January, March, May and July.

SMALL TREES, SHRUBS AND VINES.

Cephalanthus occidentalis, 9 10	Elbow-bush	**Myrica cerifera**, 6-11	Myrtle
Hypericum fasciculatum		Hypericum **myrtifolium**, 4	
Salix longipes, 9, 10	Willow	Berchemia scandens, 9-11	(Rattan vine)
		Vaccinium nitidum, 2-5, 7	Huckleberry

HERBS.

Anastrophus paspaloides	(A grass)
Spartina Bakeri	(A grass)
Drosera capillaris, 4	(Sundew)
Lemna sp., 10	(Duckweed)
Pinguicula elatior	
Viola primulifolia? 4	White violet
Hydrocotyle umbellata	
Nymphaea macrophylla, 10	Bonnets
Centella repanda, 4, 9	
Cladium effusum, 10	Saw-grass
Eupatorium capillifolium	Dog-fennel
Fimbristylis autumnalis	(A sedge)
Lachnocaulon Beyrichianum?	
Pontederia **cordata,** 10	(Pickerel weed)
Mesosphaerum radiatum, 4	
Erigeron vernus	

Rhynchospora sp.	(A sedge)
Bartonia verna	
Eleocharis interstincta	(A sedge)
Panicum paludivagum*	(A grass)
Eriocaulon compressum	
Euthamia Caroliniana	
Limnanthemum aquaticum	
Xyris sp.	
Pinguicula lutea, 4	
Syngonanthus flavidulus	
Verbena sp.	
Pinguicula pumila, 4	
Rhynchospora corniculata, 10	(A sedge)
Solidago fistulosa, 4	Goldenrod
Castalia odorata	Water-lily
Lippia sp.	

(and about 17 others seen only once)

About half the woody plants of this list are evergreen. There is only one representative of the Ericaceae, *Vaccinium nitidum,* and the Leguminosae seem to be entirely absent. The vegetation bears considerable resemblance to that in and around small lakes in the lake region,† but it includes also a few species believed to be lime-loving, most of them, however, too rare to be listed above.

About the only use made of this vegetation is as pasturage, for which it serves very well.

2. SCRUB THICKETS.

(FIGURE 59.)

Some of the prairie areas pass abruptly at their edges into high or low pine land, and some are bordered by hammocks. Many of the arms of Lake Tsala Apopka have a narrow fringe of evergreen shrubs, consisting mostly of the following species: *Ilex glabra* (gallberry), *Pieris nitida, Bejaria racemosa,* and *Pycnothymus rigidus.*

On some of the peninsulas of the same lake this fringe passes into a more extensive type of vegetation, covering several acres, which might be called scrub thicket, for want of a better name. It consists mostly of evergreen shrubs and small trees from five to ten feet in height, with no tall trees and few herbs. The soil is sandy and sterile, but contains a few burrows of some animal about two inches thick which has not been seen or identified. Fire is infrequent.

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*Formerly referred to *P. paspaloides.* See Hitchcock & Chase, Contr. U. S Nat. Herb. 15: 32-33, 1910.

†See 3d Annual Report, pp. 267-268.

The following plants were observed mostly in March, 1915, a few miles east of Inverness:

WOODY PLANTS

Quercus myrtifolia, 3, 4, 6, 7	(Scrub oak)	**Persea humilis?** 3	
Cholisma ferruginea, 3, 5, 7, 9		**Pieris nitida**, 4	(Hurrah bush)
Serenoa serrulata, 3-9	Saw-palmetto	Polycodium sp. (3, 5, 7?)	Gooseberry
Quercus geminata, 3-7	(Scrub) live oak	**Osmanthus Americana**, 3, 7-9	
Bejaria racemosa, 3-5		Batodendron **arboreum**, 3 6-9	Sparkleberry
Vaccinium nitidum, 1, 3-5, 7	Huckleberry	**Phoradendron flavescens**, 5-8	Mistletoe
Quercus **Chapmani?** 3, 7	(An oak)	**Smilax auriculata**, 3, 8, 9	(A vine)
Ceratiola ericoides, 3, 5	Rosemary	**Pycnothymus rigidus**, 4	

HERBS.

Tillandsia usneoides, 3-11	Spanish moss	**Rhynchospora dodecandra**, 7	(A sedge)

These are nearly all evergreen; Ericaceae make up about one-third of the total vegetation, and there are no Leguminosae; all of which presumably indicates a soil very deficient in soluble minerals. Besides the above flowering plants, there are a few mosses and lichens, all evergreen. The economic importance of all these plants is slight. Nearly all of them grow also in the scrub, which will be described next.

3. THE SCRUB.

(FIGURES 60, 61 AND 62.)

In some ways this is the most unique and interesting vegetation in the area under consideration. It is pretty closely correlated with a white sandy soil almost devoid of humus and animal life.* Neither mechanical nor chemical analyses of this soil from the Ocala area are available, but similar soils from the lake region and east coast have been found to be about 98% silica, with extremely small quantities of soluble matter.

The typical scrub vegetation consists of spruce pine, growing sometimes densely and sometimes scattered, with an undergrowth of semi-arborescent oaks and other evergreen shrubbery, with very few vines, briers or herbs. It is usually denser in the Ocala area than it is farther down the peninsula. In some places it passes gradually into scrub thickets (described above) or sandy hammocks (described farther on); but where it borders the high pine land the transition is usually quite abrupt, as has been remarked by several previous writers.

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*On the soil map the areas of scrub in Marion and Sumter Counties are designated "Norfolk sand with scrub oak vegetation," while those east of Silver Springs and in Citrus County, which are smaller, are not differentiated from the surrounding soils. In the chapter on soils it is stated that the white sand is a mere veneer, passing into yellowish sand at a depth of less than two inches; but this shallowness must be very exceptional, for further east and south there are railroad cuts a few feet deep through scrub, in which the sand is just as white at the bottom as it is at the top.

Fire sweeps through the scrub at long intervals, averaging perhaps once in the lifetime of a pine tree. It goes through the tops of the pines and kills them, and their wood is so soft and weak that they fall to the ground in a very few years. But very soon after the fire their cones open and discharge seeds for a new crop, and by the time the dead trees have fallen there are plenty of young ones coming up to take their places. The bushes recover from the fire much more quickly than the pines do. In its relations to fire the scrub vegetation seems to differ from any other type in the southeastern states, but is very similar to some of the coniferous forests of the far north.*

The following list, based on three days' work in March and one in July, is probably representative enough for the scrub of western Marion and eastern Citrus Counties:

TREES.

Pinus clausa, 7	Spruce pine

SMALL TREES, SHRUBS AND VINES.

Quercus myrtifolia, 2, 4, 6, 7	(Scrub oak)
Cholisma ferruginea, 2, 5, 7, 9	
Serenoa serrulata, 2, 4-9	Saw-palmetto
Garberia fruticosa	
Quercus geminata, 2, 4-7	(Scrub) live oak
Osmanthus Americana, 2, 7-9	
Batodendron arboreum, 2, 6-9	Sparkleberry
Sabal Etonia, 7	(Dwarf) cabbage palmetto
Persea humilis, 2	
Quercus Chapmani, 2, 7	(An oak)
Smilax auriculata, 2, 8, 9	(A vine)
Polycodium revolutum?	Gooseberry
Clinopodium coccineum	
Ceratiola ericoides, 2, 5	Rosemary
Vaccinium nitidum, 1, 2, 4, 5, 7	Huckleberry
Bejaria racemosa, 2, 4, 5	

HERBS.

Tillandsia usneoides, 2, 4-11	Spanish moss
Petalostemon Feayi	
Galactia regularis?	
Erythrina herbacea, 7	
Indigofera Caroliniana, 5	

There are also a few additional flowering plants seen only once each, and a few lichens and parasitic fungi.

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*See Pop. Sci. Monthly 85:358-359 Oct., 1914.

Nearly all the woody plants are evergreen. Ericaceae are pretty well represented, constituting about 25% of the shrubbery. About half the herbs are Leguminosae, strange to say, but they form only a small fraction of the total vegetation, and most of those listed were observed in an area which had been burned a few years before. (The soil must be richer in mineral nutrients immediately after a fire than at any other time, for then the potash, etc., stored up in several years' growth of leaves is returned to the soil in a very soluble form.) Grasses are wanting or nearly so, and the scrub furnishes practically no forage for cattle, or any other useful product. (The wood of the spruce pine is of very little value for lumber or fuel.) Consequently most of the scrub is likely to remain undisturbed for many years to come, and to be visited by an increasing number of scientists and nature-lovers, as other types of vegetation are gradually despoiled.

Three or four of the plants here listed are confined to Florida, and most of the others do not extend very far outside of the state (the pine only a few miles into Alabama). Very few of them reach the tropics. Similar vegetation is common in the lake region (especially in eastern Marion County), and on the old stationary dunes which border the east coast from St. John's County to the northern part of Dade. The lake region scrub is richer in species than that of the Ocala area, as seems to be the case with most vegetation types near their centers of distribution.

4. PALMETTO FLATWOODS OR LOW PINE LAND.

(FIGURE 63.)

Within the area covered by this report the low pine land is best developed in the Gulf hammock region, and in the Middle Florida flatwoods west of Dunnellon. There are also some patches a few hundred acres in extent in the northeastern part of the area, which is regarded as belonging to the lake region. It is designated on the soil map as "Leon sand" and "Leon fine sand." It is a whitish sand, said to be underlaid in many places, at a depth of a few feet, by "hardpan." Small outcrops of flinty limestone, rising a few inches above the surface, are frequent in the Gulf hammock region, but they do not seem to have much effect on the vegetation except where they are largest and closest together. The soil is damp and sour, with water not far below the surface, and apparently destitute of animal life or nearly so. It is very little cultivated at present, though it is easily tilled, and crops can be grown on it after some outlay for drainage and fertilizer.

As shown by the illustration, the vegetation usually consists of tall pines with a low dense shrubby undergrowth. Between Lake Tsala Apopka and the Withlacoochee River east of Inverness, however, trees are absent from many acres of otherwise similar vegetation, for no apparent reason. (These areas are combined with the rest in the list.) Fire occurs every few years, but does not injure the pines appreciably unless they have been turpentined, and the undergrowth recovers very quickly.

In the following list, based on observations made in March, May and July, the shrubs and herbs are combined, because they do not differ greatly in size; but the names of shrubs are preceded by S to distinguish them.

TREES.

Pinus palustris, 5, 6, 12	Long-leaf pine
Pinus serotina	(Black pine)
Pinus Elliottii	Slash pine
Magnolia glauca, 9-11	Bay

SHRUBS AND HERBS.

S Serenoa serrulata, 2, 3, 5-9	Saw-palmetto
S Ilex glabra, 2	Gallberry
Aristida stricta, 5, 6, 12	Wire-grass
S Pieris nitida, 2	(Hurrah bush)
S Vaccinium nitidum, 1-3, 5 7	Huckleberry
S Quercus minima	Oak runner
Pterocaulon undulatum, 5	(Black-root)
S Bejaria racemosa, 2, 3, 5	
S Myrica pumila, 5, 6	Myrtle
S Cholisma fruticosa	(Poor grub)
Aristida spiciformis	(A grass)
Galactia Elliottii	
Lachnocaulon anceps	
Trilisa odoratissima, 5	(Deer-tongue)
Carphephorus corymbosus, 5	
S Hypericum aspalathoides	
S Gaylussacia frondosa	Huckleberry
Xyris pallescens	
S Asimina reticulata	Pawpaw
Elephantopus nudatus? 5	
Tillandsia usneoides, 2, 3, 5-11	Spanish moss
Polygala nana	
S Pycnothymus rigidus, 2	
S Gaylussacia dumosa, 5	Huckleberry
Lechea sp.	
Pteridium aquilinum, 5, 6, 8	(A fern)
Centella repanda, 1, 9	
Drosera capillaris, 1	(Sundew)
Pinguicula lutea, 1	
Viola palmata? 6	(Blue) violet
Viola primulifolia, 1	White violet
Pinguicula pumila, 1	
Sophronanthe hispida	
Polygala setacea	
S Quercus geminata, 2, 3, 5-7	(Scrub) live oak
S Quercus myrtifolia, 2, 3, 6, 7	(Scrub oak)
S Hypericum myrtifolium, 1	
S Aronia arbutifolia	
Trilisa paniculata	
Afzelia cassioides	
Solidago fistulosa, 1	Goldenrod
Mesosphaerum radiatum, 1	
Aster adnatus	
Juncus scirpoides compositus	(A rush)
Houstonia rotundifolia, 5, 6, 8	
Hypoxis juncea	

All the trees and nearly all the shrubs are evergreen. Oaks, other than low shrubby species, seem to be entirely absent. About 35%—a very high proportion—of the shrubs are Ericaceae, and only one leguminous plant appears in the list—*Galactia Elliottii.* The pines yield lumber and turpentine, and the saw-palmetto and gallberry are important sources of honey. The various huckleberries have some food value, and at least two of the herbs, *Pterocaulon* and *Trilisa odoratissima,* have medicinal properties; so that flatwoods land ought to be worth more than scrub, even where it is not cultivated.

5. HIGH PINE LAND.

(FIGURE 64.)

This is the most extensive type of vegetation in the Ocala area, covering something like half of it. It is approximately coextensive with the "Norfolk sand," "Norfolk fine sand," and "Gainesville fine sand" of the soil map, and also covers part of the "Fellowship sandy loam" in the extreme northern portion. On the vegetation map three types of high pine land are distinguished, namely, open pine woods, pine with black-jack oak, and pine with turkey oak; but the herbaceous vegetation of all these types is so similar that it did not seem worth while to make three separate lists. The open pine woods seem to be correlated with the "Gainesville fine sand" (from which on account of its proximity to the phosphate mines most of the pine has been removed by the phosphate people, leaving large treeless wastes) and also with virgin forests. The black-jack oak abounds in the driest or barrenest portions of the high pine land, especially where the largest pines have been cut out by lumbermen. Where the turkey oak predominates it seems to indicate soils of a little finer texture or perhaps more phosphatic than the average, though it commonly associates with the black-jack and is less abundant.

The soil is mostly sand, with 2 to 8% of silt and clay, several feet deep. Generally it has a very loose texture and a pale buff color, varying toward white, yellow, brown or gray in different places. Small outcrops of flinty limestone are occasionally seen, but seem to have little or no effect on the vegetation. Humus is absent or nearly so, on account of frequent fires and lack of shade, and the groundwater stands several to many feet below the surface; rarely high enough, in fact, to be brought up by suction pumps. There are whole townships of high pine land in which there is no surface water whatever.

The subterranean fauna of the high pine land is very characteristic. On every acre of it, especially in spring, low mounds of sand a foot or two in diameter, made by the "salamander," (a rodent, *Geomys Tuza Floridanus**) are rather conspicuous. Ant-hills, and diminutive mounds made by some unidentified animal with a burrow about three-eighths of an inch in diameter, are frequent, and burrows of the "gopher" (a turtle, *Testudo* or *Gopherus Polyphemus*) and pits of the "doodle-bug" or ant-lion are occasional. These animals together must move almost every particle of the uppermost foot or two of the soil every few years, and counteract to a very large extent the leaching effect of the summer rain, which is probably what has made the relatively lifeless soil of the scrub and damp flatwoods so poor.

An equally important factor in the development of high pine land vegetation is fire. Every tree in this type has its bark blackened at the base, and every stump and prostrate log is charred, from the fires which probably recur at any one point about once in two years, on the average. These fires, quite different from the forest fires of the far north, run through the grass and only occasionally get up into the tree-tops, and then only in isolated cases, not spreading from tree to tree as they do in the scrub and the dense northern coniferous forests. In pre-historic times lightning must have been the principal agency for starting fire. Although lightning is usually accompanied by rain, a pine tree set on fire by it (as often happens) might continue to burn until after the sun came out and the grass dried off, and then fall over and set the grass on fire. And although fire might not be started in this way on any one square mile more than once in several decades, a fire in an unbroken pine forest could easily spread over many square miles, so that every acre of such forest would be likely to be burned over every few years. The fires are most frequent in early spring.

The Indians, imitating Nature, fired the woods at more or less regular intervals to keep down the underbrush and facilitate hunting, it is said, and civilized man keeps up the practice for various reasons, such as to improve grazing and to prevent injury to turpentined trees by having too much inflammable material burn at once, as might happen if several years elapsed between fires. Many fires are also set accidentally or carelessly; but now there are so many roads, railroads, clearings, and other barriers that any one fire cannot spread as far as formerly, and the frequency of fire at any one point in the pine land may be no greater now than it was originally. (In the West prairie fires are said to have been greatly decreased by civilization). At any rate, there is no evidence that the change in frequency of fire in the high pine land, one way or the other, has been enough to have any appreciable effect on the vegetation.

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*For notes on the distribution and habitats of this animal in Florida and adjoining states see Science II. 35:115-119. Jan. 19, 1912.

The long-leaf pine has such thick fire-proof bark that fire does little or no harm to it after it is three or four years old, provided it has not been turpentined,* so that in any spot which escapes burning for that length of time there is a chance for the pine to reproduce itself, provided there has been a good seed year just before.† (The long-leaf pine produces seed in abundance only about once in five years, it is said.‡) And such an opportunity need come only two or three times in a century to insure the perpetuation of the forest. The oaks of the pine land seem to resist fire equally well, and nearly all the shrubs and herbs have underground rootstocks which send up new shoots very soon after a fire, making a fresh green carpet.

The foregoing paragraphs explain how fire starts in the pine lands and how the plants are protected against it. The vegetation not only endures fire, but is also benefited by it, as will now be shown. In the first place, in an area which had not been burned for several years most of the pine seeds would probably lodge in the grass and fail to germinate; but those that fall soon after a fire, when the ground is bare or nearly so, take root readily, especially if they fall where the soil has just been loosened up by salamanders (which seem to be most active just after a fire). It can hardly be doubted that fire also tends to keep in check some insects which would otherwise injure the trees, but this point does not seem to have been specially investigated.

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*It is customary to remove the grass and pine straw for a space of a few feet around every boxed tree about once a year to minimize the danger from fire.

†It is probable that the salamander indirectly helps the long-leaf pine to perpetuate itself in spite of fire, for a seed falling in the middle of a fresh salamander hill could germinate and grow for a year or two at least without having any inflammable material within several inches of it.

‡1913 was evidently a good seed year in Citrus County, and in March, 1914, the writer noticed pine seedlings two or three inches high growing over large areas in that county at the rate of three or four to the square foot or about 100,000,000 to the square mile. If only one in a thousand of these grows to maturity it will be enough to make a good stand of timber.

ILLUSTRATIONS.

TO ACCOMPANY PAPER ON THE

NATURAL RESOURCES OF AN AREA IN CENTRAL FLORIDA.

FIGURES 54 TO 70.

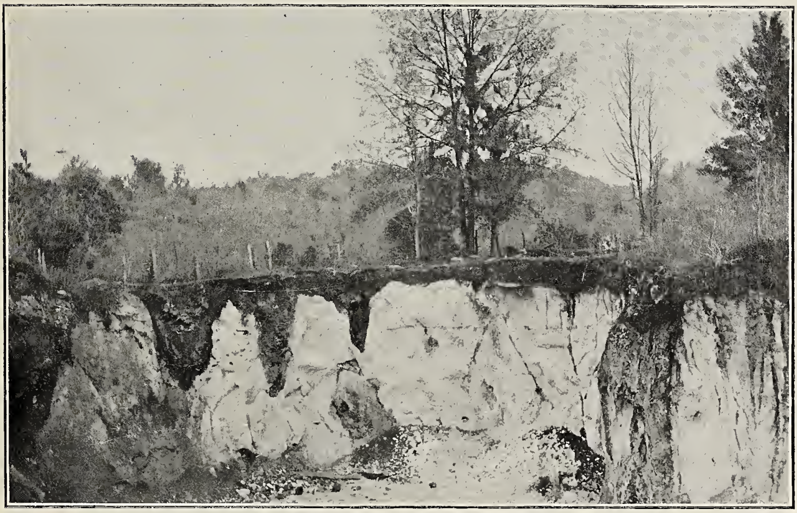


Fig. 54.—View in the lime pit of the Florida Lime Company, Ocala.

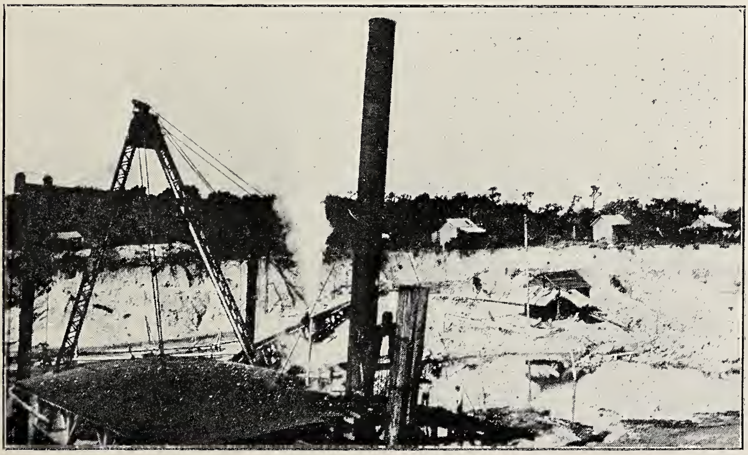


Fig. 55.—View in pit of the Buttenbach Phosphate Company mine near Dunnellon, showing method of mining phosphate rock by floating dredge.

SPRINGS OF CENTRAL FLORIDA.

Fig. 56.—Silver Springs in Marion County. Flow 368,913 gallons per minute.

VEGETATION TYPES.

Fig. 57.—Small prairie surrounded by pine woods, just southwest of Wildwood, Sumter Co., in the dry season. (Soil mapped as "Portsmouth sand.") March 10, 1914.

Fig. 58.—Prairie vegetation in shallow arms of Lake Tsala Apopka (nearly dry at this time) about 3 miles each of Inverness. Abrupt transition to sandy hammock vegetation on slightly higher ground (peninsulas) on either side. March 15, 1914.

VEGETATION TYPES.

Fig. 59.—Scrub thicket on a peninsula of Lake Tsala Apopka about 4 miles east of Inverness. Vegetation mostly *Quercus geminata, Q. myrtifolia, Cholisma* and *Ceratiola.* Camera held about 6 feet from the ground. March 15, 1914.

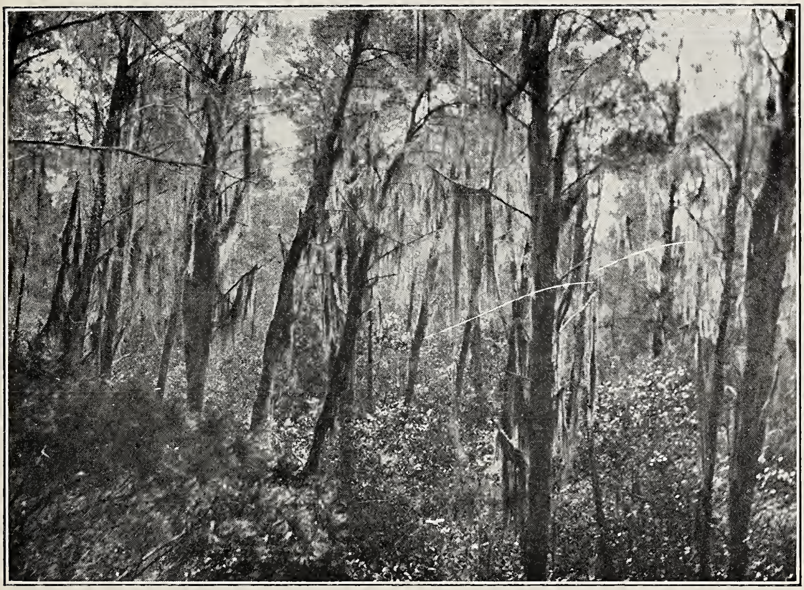
Fig. 60.—Rather open scrub about 5 miles west of Inverness, taken from a point about 20 feet from the ground. (Soil mapped as "Norfolk fine sand.")

Fig. 61.—Burned area in scrub about 1½ miles northeast of Silver Springs, in which the trees have all decayed and fallen. In the background is a dense stand of middle-aged spruce pine, probably dating from a fire 20 or 25 years ago. (Soil mapped as "Leon sand.") March 11, 1914.

VEGETATION TYPES.

Fig. 62.—Interior of dense scrub on a peninsula of Lake Tsala Apopka, about 3 miles east of Inverness, from a point about 20 feet from the ground. The size of the trees and the abundance of "moss" indicates that there has been no fire here for many years.

Fig. 63.—Flatwoods a few miles west of Wildwood, Sumter Co., with longleaf pine, gallberry and saw-palmetto. The largest pines have been cut for lumber. (Soil mapped as "Leon sand.") March 10, 1914.



VEGETATION TYPES.

Fig. 64.—High pine land with scattered oaks, about 5 miles west of Inverness, Citrus Co. The largest oak is a live oak (*Quercus geminata.*) (Soil mapped as "Norfolk fine sand.") March 14, 1914.

Fig. 65.—Red oak woods about 1½ miles E. S. E. of Ocala. Trees in foreground red oak (*Quercus falcata*), others mostly sweet gum (*Liquidambar*); all deciduous. Locality for soil sample corresponding to chemical analysis. No. 2 (mapped as "Gainesville loamy sand"). Feb. 13, 1915.

VEGETATION TYPES.

Fig. 66.—Sandy hammock about 6 miles south of Ocala, with holly (*Ilex opaca*), saw-palmetto, and other evergreens. Locality for soil samples corresponding to chemical analysis No. 3 (mapped as "Leon sand"). Feb. 14, 1915.

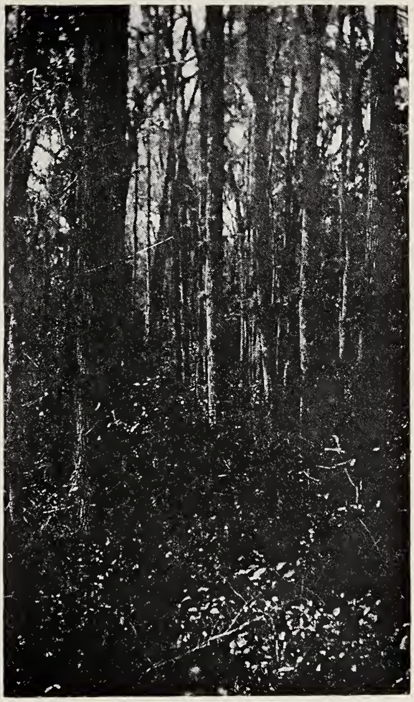
Fig. 67.—Hammock about a mile southeast of Ocala, with magnolia, oak (*Quercus laurifolia*), red bay (*Persea Borbonia*), sweet gum, etc. Locality for soil sample corresponding to chemical analysis No. 4 (mapped as "Gainesville sandy loam"). Feb. 13, 1915.

VEGETATION TYPES.

Fig. 68.—Swampy spot in low calcareous hammock 1½ miles south of Wildwood, with cypress, air-plant (*Tillandsia tenuifolia*), *Saururus,* etc. May 17, 1910.

Fig. 69.—Swamp a few miles west of Wildwood, with trees mostly black gum. March 10, 1914. (This view is very near the edge of the swamp, where there was no calciphile vegetation in evidence, but it is doubtless more typical farther in, for this swamp borders Lake Panasoffkee, a rather calcareous body of water, and is designated on the soil map as "swamp, marl subsoil phase.")

Fig. 70.—Western edge of short-leaf pine and cabbage palmetto bottoms ("Fellowship clay") about 2 miles northeast of Silver Spring. The perspective of the railroad track shows plainly that it is lower than the pine land in the foreground. March 11, 1914.



Second, fire returns quickly to the soil the potash and other minerals stored up in pine straw and other dead leaves, and thus allows the pine to do a large business on a small capital, so to speak. For the soil is not very rich in soluble minerals, and these when taken up by plants are concentrated chiefly in the leaves. which in the case of most high pine land plants are tough and decay slowly; so that if many years elapsed between fires most of the mineral plant food near the surface might be locked up in an accumulation of dead leaves, and the trees would be threatened with starvation.

Finally. if fires should cease entirely, it is reasonably certain that the high pine land vegetation would be gradually replaced by that of the sandy hammocks described below. For although there is little or no original or geological difference in the soil of the two types, the hammock trees seem to require humus and are sensitive to fire, and consequently they cannot invade the pine land very fast as long as fires prevail. The long-leaf pine, on the other hand, cannot stand much shade and crowding, so that it could not compete successfully with the hammock trees on their own ground. At the edge of a hammock the leaves of the trees must be continually falling a little way out in the pine land, thus giving the humus-loving trees a chance to slowly encroach on the pines.

It is very interesting to observe on the vegetation map that the high pine land almost nowhere forms small patches or narrow tongues bordered by water or by vegetation not much subject to fire. The explanation is probably that fire could not easily run into such places often enough to protect the pines from the encroachments of hardwoods.*

The following list of high pine land plants is based on observations made in the Ocala area on 20 different days, in the months of January, March, April, May and July. No doubt field work in the fall would quickly reveal several additional herbs; though some of the fall-blooming ones have stiff stems which stand up through the winter and spring (or until the next fire), and thus enable the plants to be recognized in winter. Shrubs and herbs are lumped together, as was done in the case of the flatwoods, for otherwise in the absence of percentage figures there would be nothing to indicate the relative abundance of the commonest shrub, saw-palmetto. and the commonest herb, wire-grass. The names of shrubs are preceded by S.

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*For additional notes on the influence of fire on long-leaf pine forests see Geol. Surv. Ala. Monog. 8:25-27. June, 1913; Literary Digest 47:208. Aug. 27, 1913; American Forestry 19:667-669. Oct., 1913; Forestry Quarterly 11:545-546. Dec., 1913; Pop. Sci. Monthly 85:353-355. Oct., 1914; Fla. Geol. Surv. 6th Ann. Rep. 184-185, 362, 384. Dec., 1914.

TREES.

Pinus palustris, 4, 6, 12	Long-leaf pine	**Quercus geminata,** 2-4, 6, 7	Live oak
Quercus Catesbaei	Black-jack oak*	Quercus Margaretta	Post oak
Quercus cinerea	Turkey oak†	Quercus falcata, 6, 8	Red oak
		Crataegus Michauxii? 6	Red haw
		Hicoria alba? 6	Hickory

SHRUBS AND HERBS.

	Aristida stricta, 4, 6, 12	Wire-grass
	Kuhnistera pinnata	(Summer farewell)
	Eriogonum tomentosum, 6	
	Tillandsia usneoides, 2-4, 6-11	Spanish moss
	Eupatorium compositifolium	Dog-fennel
	Chamaecrista sp.	(Partridge pea)
	Carphephorus **corymbosus,** 4	
S	**Serenoa serrulata,** 2-4, 6-9	Saw-palmetto
	Andropogon Virginicus	Broom-sedge
	Actinospermum angustifolium	
	Eupatorium aromaticum, 6	
	Pterocaulon undulatum, 4	(Black-root)
S	Chrysobalanus **oblongifolius,** 6	
S	**Myrica pumila,** 4, 6	Myrtle
	Croton argyranthemus	
	Pteridium aquilinum, 4, 6, 8	(A fern)
	Sericocarpus bifoliatus, 6	
	Stillingia sylvatica	(Queen's delight)
S	Asimina speciosa	Pawpaw
S	**Vaccinium nitidum,** 1-4, 7	Huckleberry
	Psoralea canescens	
S	**Ceanothus microphyllus**	
	Galactia mollis?	
	Cyperus Martindalei	(A sedge)
	Helianthus Radula	(Sunflower)
	Mesadenia Floridana, 6	
	Berlandiera subacaulis, 6	
	Stylosanthes biflora	
	Elephantopus **nudatus?** 4	
	Sporobolus gracilis	(A grass)
	Aeschynomene viscidula	
	Piriqueta Caroliniana	
	Cracca chrysophylla	
S	Diospyros Virginiana, 9	Persimmon
S	**Cholisma ferruginea,** 2, 3, 7, 9	
S	Rhus Toxicodendron	Poison oak
S	Polycodium caesium	Gooseberry
	Chrysopsis graminifolia	
	Chapmania Floridana	
	Helianthella	
	Silphium compositum	
	Calophanes oblongifolia	
	Stenophyllus Warei	(A sedge)
	Andropogon Elliottii?	Broom-sedge
	Vernonia angustifolia	(Ironweed)
	Meibomia rigida	(Beggar-lice)
	Dolicholus simplicifolius	(Dollar-weed)
	Psoralea Lupinellus	
S	Rhus copallina, 6	Sumac
S	**Phoradendron flavescens,** 2, 6-8	Mistletoe
	Lygodesmia aphylla	
	Chrysopsis gossypina	
	Eupatorium album	
	Polygala grandiflora	
	Cenchrus incertus?	Sand-spur
	Schoenocaulon gracile	
	Stenophyllus ciliatifolius	(A sedge)
S	Asimina angustifolia	Pawpaw
	Solidago odora	Goldenrod
	Gaillardia lanceolata	
	Cnidoscolus stimulosus	Stinging nettle
	Breweria humistrata	
	Laciniaria gracilis?	
	Asclepias verticillata	(Milkweed)
	Houstonia rotundifolia, 4, 6, 8	
	Opuntia vulgaris, 7	Prickly pear
S	**Ceratiola ericoides,** 2 3	Rosemary
	Laciniaria tenuifolia	
	Trilisa odoratissima, 4	Deer-tongue
	Thysanella fimbriata	
	Rhynchospora Grayii	(A sedge)
	Galium pilosum?	
	Dasystoma pectinata	
	Cracca spicata?	
	Gaura Michauxii	

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*In Georgia this is often called turkey oak or forked-leaf black-jack, to distinguish it from the ordinary or round-leaf black-jack, *Q. Marylandica,* which is commoner there.

†Also called upland willow oak or narrow-leaf black-jack farther north.

	Commelina angustifolia?	
	Scutellaria multiglandulosa	
	Euphorbia cordifolia	
S	**Baccharis halimifolia**, 9	
	Verbena carnea	
S	Castanea alnifolia	Chinquapin
S	**Bejaria racemosa**, 2-4	
	Asclepias humistrata	Milkweed
S	Gaylussacia **dumosa**, 4	Huckleberry
	Eriogonum Floridanum	
	Aster concolor	
	Tillandsia recurvata	Air-plant
	Sisyrinchium sp.	
	Gerardia divaricata?	
	Onosmodium sp.	
	Zamia integrifolia	Coontie
	Lupinus diffusus	
	Scleria glabra	(A sedge)
	Gymnopogon ambiguus	(A grass)
	Aster squarrosus	
	Petalostemon albidus	
	Indigofera Caroliniana, 3	

The only evergreen trees are the pine and live oak, but they make up about 75% of the bulk of the vegetation. About three-fourths of the shrubs too are evergreen, and about 15% of them are Ericaceae. Something like 16% of the herbs are Leguminosae—a pretty high proportion. Mosses, lichens, and woody vines are rare or absent, being very sensitive to fire. In the Ocala area the high pine land is almost co-extensive with the lime-sink region, and the relative abundance of the species above listed is much the same as in the list of lime-sink region plants from a little farther north, listed in the 6th Annual Report, pages 316-318. Most of the species have a pretty wide distribution in Florida and the southern parts of adjoining states, where the soils are pretty sandy and the summers wetter than the winters. *Mesadenia Floridana, Chapmania,* and a few of the rarer species are confined to Florida.

The long-leaf pine is an important source of fuel, fence-posts (and formerly fence-rails, which are little used now), lumber and naval stores, and the wire-grass and other herbs feed thousands of cattle, whose raising costs almost nothing. In the vicinity of the phosphate mines in the western part of the area nearly all the pine has been cut off from thousands of acres for the purpose of drying the phosphate rock after it is washed, giving the country a very desolate appearance; but young pines are springing up abundantly in many places, and the forests will readily re-establish themselves if given a chance.

A considerable part of the high pine land is now under cultivation. Although the soil is naturally less fertile than that of the red oak woods and high hammocks near by, it is much easier to clear and somewhat easier to plow, and a small expenditure for fertilizer brings handsome returns in crop yields.

6. RED OAK WOODS.

(FIGURE 65.)

This type of vegetation is usually located between high pine land and high (clayey or calcareous) hammocks, and it grades into both in soil and in vegetation, making a connecting link between two dissimilar types. In its most typical development it corresponds approximately with the "Gainesville loamy sand" of the soil map. On the vegetation map the extreme phase with little or no pine is combined with the hammocks, and only the phase with red oak and long-leaf pine mixed mapped separately.

The soil is usually sandy at the surface, but contains considerable amounts of clayey, calcareous and phosphatic material, probably varying a good deal in short distances. It is one of the richest upland soils in the state, especially in phosphorus. (See chemical analysis No. 2, page 123.)

Salamanders go into this type of vegetation just about as far as the long-leaf pine does, but some of the other characteristic subterranean animals of the high pine land have not been observed.

The red oak woods resemble the high pine land in having little underbrush, but in their typical or extreme development, where the trees are all deciduous, they are rather shady, and have considerable humus and very little herbaceous vegetation. As the pine land is approached they become more open, wire-grass and other pine land herbs appear, and evidences of fire become more frequent.

The following list is based on observations made within a few miles of Ocala in February and March, and may not be very complete for the herbs. Shrubs and vines are combined, but the names of the vines are distinguished by V.

TREES.

Quercus falcata, 5, 8	Red oak	**Quercus laurifolia**, 7, 8	(An oak)
Pinus palustris, 4, 5, 12	Long-leaf pine	Cornus florida, 7, 8	Dogwood
Hicoria alba? 5	Hickory	Hicoria glabra? 7, 8	Hickory
Liquidambar Styraciflua, 7-11	Sweet gum	**Persea Borbonia**, 7, 8	(Red bay)
Pinus Taeda, 8, 10, 11	Short-leaf pine	Quercus **nigra**, 7-9, 11	Water oak
		Ilex opaca, 7-9, 11	Holly
		Cercis Canadensis, 8	Redbud

SMALL TREES.

Crataegus Michauxii? 5	Red haw	Batodendron **arboreum**, 2, 3, 7-9	Sparkleberry
Quercus geminata, 2-5, 7	Live oak		
Xanthoxylum Clava-Herculis	(Prickly ash)		

SHRUBS AND VINES.

Myrica cerifera,* 1, 7-11	Myrtle
Myrica pumila,* 4, 5	Myrtle
Phoradendron flavescens, 2, 5, 7, 8	Mistletoe
Quercus myrtifolia? 2-4, 7	(Scrub oak)
Rhus copallina, 5	Sumac
Serenoa serrulata, 2-5, 7-9	Saw-palmetto
V Parthenocissus quinquefolia, 8, 11	Virginia creeper

Chrysobalanus **oblongifolius,** 5	
Callicarpa Americana, 7-9	French mulberry
Aralia spinosa, 9	Prickly ash
V **Smilax lanceolata,** 8	(Wild smilax)
V **Gelsemium sempervirens,** 7, 8	Yellow jessamine
V **Rubus trivialis,** 8	Dewberry

HERBS.

Tillandsia usneoides, 2-5, 7-11	Spanish moss
Pteridium aquilinum, 4, 5, 8	(A fern)
Aristida stricta, 4, 5, 12	Wire-grass
Houstonia rotundifolia, 4, 5, 8	
Viola palmata? 4	(Blue) violet
Berlandiera subacaulis, 5	
Eriogonum tomentosum, 5	

Sericocarpus bifoliatus, 5
Elephantopus tomentosus? 8
Eupatorium aromaticum, 5
Helianthemum Carolinianum
Mesadenia Floridana, 5
Salvia lyrata, 8
Conopholis Americana, 7-9
(and a few others seen only once.)

The red oak and the first hickory listed are especially characteristic of this type of vegetation, and in central Florida almost confined to it; but most of the other species are equally at home either in the high pine land or in the calcareous hammocks to be described below. The percentage of evergreens varies from nothing in the richest spots to about 70% at the edge of the pine land, and probably averages about 35%, a very low figure for Florida. (This vegetation bears considerable resemblance to the oak and hickory woods of the Wakulla hammock country, described in the 6th Annual Report, pages 291, 379, 397.) The red oak, although this is just about the southern limit of its range, grows just about as large here as it does anywhere.

The scattered pines have been utilized to some extent for lumber and turpentine, and the oaks and hickories for fuel. The Spanish moss which is gathered in a small way for mattress-making in this part of the state probably comes mostly from the red oak woods, because it is more abundant there than in the other types of forest. The soil is very fertile, and there is no telling how much of the original red oak woods has been replaced by cultivated fields; probably at least half.

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*In the red oak woods there seem to be all gradations between these two ordinarily distinct shrubs.

7. SANDY HAMMOCKS.

(FIGURES 58, 66.)

This type of vegetation occurs mostly on soils which were probably originally the same as that of the high pine land, namely, "Norfolk sand" and "Norfolk fine sand." There is also several hundred acres of it about six miles south of Ocala on soil mapped as "Leon sand." It is best developed in the areas last mentioned, on the north and south sides of the large patch of scrub about four miles west-southwest of Ocala, and on the numerous peninsulas around Lake Tsala Apopka. It grades into two other types which are very distinct from each other, namely, scrub and high clay hammocks.

The soil is sandy and loose, with usually enough humus to give it a light gray tint. The leaves of which the humus is chiefly composed decay very slowly, partly because of their leathery texture, and partly because of the scarcity of animal and bacterial life in the soil. Outcrops of flinty limestone are seen in a few places, but they seem to have little or no effect on the vegetation. No soil animals have been noticed, but they are probably not entirely wanting. Apparently the dense shade, or the scarcity of grass or some other food plant, discourages the salamanders, and without their assistance in stirring up the soil the potash and other mineral nutrients are probably gradually being leached downward beyond the reach of the roots. For a chemical analysis of this type of soil see No. 3, page 123.

The sandy hammock vegetation consists mostly of trees and shrubs with stiff evergreen leaves, growing closely enough so that little sunlight ever reaches the ground. Most of the trees have rather crooked trunks, a fact probably correlated with the sterility of the soil, and there are all gradations in size between trees and shrubs.

Fire is a rare occurrence; originally because of the protection afforded by water or scrub or high hammocks* on one or more sides, and now because there is very little grass in the hammocks to feed flames, and the humus does not burn readily. Even if all the sandy hammock was not once pine land, it is reasonably certain that it has superseded some of the scrub and high pine land, and that the process of encroachment is still going on, though perhaps at a rate so slow as not to be perceptible in a human lifetime. (This point was discussed at some length, with illustrations from the peninsulas of Lake Tsala Apopka, by the writer a few years ago,* and has also been explained above under the head of high pine land.)

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*The fact that the areas of "Leon sand" a few miles south of Ocala, which are almost surrounded by high hammocks, are covered with sandy hammock vegetation, instead of the pine forests normal to such soils, is very significant. All the sandy hammocks on the map are partly protected from fire in one way or another.

The following list is based on observations made in January, February, March and July.

TREES.

Quercus laurifolia, 6, 8	(An oak)
Magnolia grandiflora, 8, 9	Magnolia
Persea Borbonia, 6, 8	Red bay
Quercus geminata, 2-6	(Scrub) live oak
Hicoria glabra? 6, 8	Hickory
Cornus florida, 6, 8	Dogwood
Quercus Virginiana, 8, 9	Live oak
Ilex opaca, 6, 8, 9, 11	Holly
Liquidambar Styraciflua, 6, 8-11	Sweet gum
Quercus **nigra**, 6, 8, 9, 11	Water oak
Pinus clausa, 3	Spruce pine
Sabal Palmetto, 8-11	Cabbage palmetto
Ostrya Virginiana, 8	
Tilia pubescens? 8	Lin (basswood)

SMALL TREES OR LARGE SHRUBS.

Batodendron **arboreum**, 2, 3, 6, 8, 9	Sparkleberry
Osmanthus Americana, 2, 3, 8, 9	
Cholisma ferruginea, 2, 3, 5, 9	
Quercus **Chapmani**, 2, 3	(An oak)
Bumelia tenax?	
Quercus myrtifolia, 2, 3, 4, 6	(Scrub oak)
Myrica cerifera, 1, 6, 8-11	Myrtle
Ilex Cassine, 9	
Viburnum rufidulum, 8	Black haw

WOODY VINES.

Vitis rotundifolia, 8, 9	Bullace (muscadine)
Gelsemium sempervirens, 6, 8	Yellow jessamine
Vitis aestivalis? 8, 11	Wild grape

SHRUBS.

Serenoa serrulata, 2-6, 8, 9	Saw-palmetto
Phoradendron flavescens, 2, 5, 6, 8	Mistletoe
Callicarpa Americana, 6, 8, 9	French mulberry
Polycodium sp. (2, 3, 5?)	Gooseberry
Sabal Etonia? 3	Palmetto
Vaccinium nitidum, 1-5	Huckleberry
Amorpha fruticosa	

HERBS.

Tillandsia usneoides, 2-6, 8-11	Spanish moss
Smilax pumila, 8	
Mitchella repens, 8, 9, 11	(Turkey-berry, partridge berry
Rhynchospora dodecandra, 2	(A sedge)
Polypodium polypodioides, 8, 9, 11	(A fern)
Tillandsia tenuifolia, 8, 9, 11	Air-plant
Erythrina herbacea, 3	
Scleria triglomerata, 8, 9	(A sedge)
Opuntia vulgaris? 5	Prickly pear
Epidendrum sp., 8-11	(An orchid)
Oplismenus setarius, 8, 9, 11	(A grass)
Elephantopus sp.	
Carex Floridana, 8	(A sedge)
Conopholis Americana, 6, 8, 9	
Carex dasycarpa	(A sedge)

(Also a few lichens and mosses.)

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*Bull. Torrey Bot. Club 38:515-525. 1911.

About 80% of this vegetation is evergreen. Ericaceae are relatively abundant, especially among the small trees, and there are only two leguminous plants in the list, *Amorpha* and *Erythrina*. All this indicates that the soil is not very productive, notwithstanding its considerable humus content and the density of the vegetation, which might deceive a person not accustomed to these conditions. This is evidently realized by the farmers, who have made little attempt to cultivate any of the sandy hammock land. The vegetation as a whole is more ornamental than useful.*

Intermediate hammocks. There are a few hammocks in the vicinity of Ocala intermediate between the sandy hammocks and the type next to be described. Most of them are surrounded by high pine land, and the reason for their existence is not apparent until they are entered and found usually to have for a nucleus a small pond or sink-hole. The soil is usually a little rocky, and presumably somewhat richer in plant food than that of the high pine land and sandy hammocks. Probably each hammock of this kind originated as a small patch of hardwood trees in a sink-hole, or a fringe of them around a pond, where there was some protection from fire, and gradually spread outward from the center, their growth being facilitated by the moderately fertile soil. The vegetation in such places seems to contain no plants that are not found in one of the other kinds of hammocks, and it need not be described here.

8. (CALCAREOUS) HIGH HAMMOCKS.

(FIGURE 67.)

This type of vegetation is common within a few miles of Ocala, on various soils of the "Fellowship" and "Gainesville" series; and most of it is at a little higher elevation than the prevailing pine lands, as can be seen from the contours on the soil map.

The soil consists of sand, clay and rock mixed in various proportions, and varying considerably in short distances. Some of the rock, especially around sinks and caves, is a nearly pure soft limestone (Ocala formation), but a good deal of it is a sort of friable gritty sandstone of later age (presumably the Alum Bluff formation). The soil at its poorest extreme does not differ much from that of the high pine land, but at the other extreme it is a rich black calcareous loam, with as much as 42% of silt and clay by mechanical analysis, and over 7% of lime by chemical analysis. (See chemical analyses 1, 4, and 5.) Salamanders are absent, except in clearings, but there are probably other subterranean animals which help maintain the fertility of the soil. Fire is a negligible factor. The soil is so fertile that it has probably never (at least in the last few thousand years) supported pine forests and other inflammable vegetation, and the aspect of the high hammocks probably has not changed much since pre-historic times, except for the interference of man.

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*Much of this paragraph and of the foregoing plant list would apply equally well to the so-called "pocosin" of Pike County, Ala., which is a sandy hammock, described by the writer in Bull. Torrey Bot. Club 41:209-220. 1914.

The vegetation looks something like that of the sandy hammocks, but the trees are taller and straighter, and there is less underbrush. On the richest spots the trees are nearly all deciduous, but the proportion of evergreens increases with the sandiness of the soil. The extremes are different enough to be classed as different types, if they were not connected by all possible gradations.

The following list is based on observations made in February, March and July, but mostly in March.

TREES.

Magnolia grandiflora, 7, 9	Magnolia
Liquidambar Styraciflua, 6, 7, 9-11	Sweet gum
Quercus laurifolia, 6, 7	(An oak)
Quercus Michauxii, 11	White oak
Persea Borbonia, 6, 7	(Red bay)
Ostrya Virginiana, 7	
Tilia pubescens? 7	Lin (basswood)
Hicoria glabra? 6, 7	Hickory
Quercus **nigra,** 6, 7, 9, 11	Water oak
Cornus florida, 6	Dogwood
Fraxinus Americana?	Ash
Cercis Canadensis, 6	Redbud
Sabal Palmetto, 7, 9-11	Cabbage palmetto
Pinus Taeda, 6, 10, 11	Short-leaf pine
Carpinus Caroliniana, 9, 11	Ironwood
Ulmus alata, 11	Elm
Quercus Virginiana, 7, 9	Live oak
Quercus Schneckii	(Red oak)
Celtis occidentalis? 9	Hackberry
Acer Floridanum	Sugar maple
Prunus Caroliniana	(Mock orange)
Acer Negundo, 11	(Box elder)
Morus rubra, 9, 11	Mulberry
Quercus falcata, 5, 6	Red oak
Quercus Floridana?	(An unidentified white oak)
Ilex opaca, 6, 7, 9, 11	Holly
Juniperus Virginiana	Cedar

SMALL TREES.

Osmanthus Americana, 2, 3, 7, 9	
Batodendron arboreum, 2, 3, 6, 7, 9	Sparkleberry
Viburnum rufidulum, 7	Black haw
Prunus umbellata?	(Hog plum)
Crataegus apiifolia, 9, 11	(Parsley haw)
Myrica cerifera, 1, 6, 7, 9-11	Myrtle

WOODY VINES.

Rhus radicans, 9-11	Poison ivy
Smilax lanceolata, 6	(Bamboo, wild smilax)
Vitis rotundifolia, 7. 9	Bullace (muscadine)
Bignonia crucigera, 9	Cross-vine
Parthenocissus quinquefolia, 6, 11	Virginia creeper
Gelsemium sempervirens, 6, 7	Yellow jessamine
Vitis aestivalis? 7, 11	Wild grape
Rubus trivialis, 6	Dewberry
Smilax rotundifolia? 11	
Smilax auriculata, 2, 3, 9	

SHRUBS.

Ilex vomitoria, 9	(Yaupon)
Callicarpa Americana, 6, 7, 9	French mulberry
Cornus stricta? 9, 10	
Euonymus Americanus	
Forestiera ligustrina	
Serenoa serrulata, 2-7, 9	Saw-palmetto
Phoradendron flavescens, 2, 5-7	Mistletoe
Sabal glabra, 9, 11	Palmetto
Viburnum obovatum, 9-11	
Sageretia minutiflora, 9	
Asimina parviflora	Pawpaw

HERBS

Tillandsia usneoides, 2-7, 9-11	Spanish moss
Tubiflora Carolinensis, 9, 11	
Oplismenus setarius, 7, 9, 11	(A grass)
Mitchella repens, 7, 9, 11	(Turkey-berry, partridge berry)
Dryopteris patens? 11	(A fern)
Smilax pumila, 7	
Tillandsia tenuifolia, 7, 9, 11	(Air-plant)
Asplenium resiliens	(A fern)
Eupatorium ageratoides?	
Viola multicaulis	Violet
Pteridium aquilinum, 4-6	(A fern)
Arisaema Dracontium	
Salvia lyrata, 6	(Sage)
Epidendrum conopseum, 7, 9-11	(An orchid)
Viola sp.	(Blue) violet
Elephantopus tomentosus? 6	
Asplenium firmum	(A fern)
Elephantopus Carolinianus	
Scleria triglomerata, 7, 9	(A sedge)
Asplenium platyneuron	(A fern)
Houstonia rotundifolia, 4-6	
Polypodium polypodioides, 7, 9, 11	(A fern)
Galium uniflorum	
Cyperus echinatus?	(A sedge)
Carex Floridana, 7	(A sedge)
Conopholis Americana, 6, 7, 9	
Corallorhiza Wisteriana	(An orchid)
Viola villosa	Violet

(Also about a dozen rarer herbs, and a few mosses, etc.)

About 40% of the vegetation is evergreen, a somewhat higher figure than in the case of the red oak woods, but much lower than that of the otherwise similar sandy hammocks. This difference is unquestionably correlated with the richness of the soil. The abundance of vines is a good indication of the rarity of fire. Only one representative of the Ericaceae (*Batodendron*) is listed, and no Leguminosae. The scarcity of the former is probably correlated with the lime or potash in the soil, and of the latter with the abundance of humus. Most of the ferns grow on calcareous rocks in sinks or around mouths of caves, and it is not yet certain whether lime or shade or protection from fire is the most important factor for them.

The high hammock soil is excellent for both general farming and trucking, and possibly the principal reason why it is not all under cultivation is that it is so much more expensive to clear than the high pine land, and not quite so easy to plow. The native plants do not seem to be put to any important use. Some of the hardwood timber would be valuable, but any one species grows so scattered that it might not pay yet to try to utilize it on a commercial scale.

9. (CALCAREOUS) LOW HAMMOCKS.

(FIGURE 68.)

In the Ocala area these are almost confined to the Gulf hammock region, and correspond approximately with the "Parkwood" soils on the soil map. They are nearly always a little lower than the surrounding country, and damp, but hardly wet enough to be called swamps; although some of them have low wet spots with essentially the same kind of vegetation as the swamps to be described next. The soil consists of marl, clay, sand and humus in varying proportions, and is evidently pretty well supplied with lime, if not with potash. Soil animals have not been noticed, but conditions ought to be favorable for crawfish, if those occur so far south.

The trees are mostly tall and straight, and make a dense shade. The humus probably seldom or never gets dry enough to burn, so that fire does not need to be reckoned with. The following plants have been noted in low hammocks in the months of February, March and May.

TREES.

Carpinus Caroliniana, 8, 11	Ironwood	**Persea pubescens?**	(Red bay)
Quercus Virginiana, 7, 8	Live oak	Celtis occidentalis? 8	Hackberry
Liquidambar Styraciflua, 6-8, 10, 11	Sweet gum	Ulmus Floridana, 10, 11	Elm
Sabal Palmetto, 7, 8, 10, 11	Cabbage palmetto	Hicoria sp.	Hickory
Taxodium distichum, 10, 11	Cypress	**Magnolia glauca**, 4, 10, 11	(White) bay
Magnolia grandiflora, 7, 8	Magnolia	Fraxinus Caroliniana? 10, 11	Ash
Quercus hybrida? 11	(Water oak?)	Morus rubra, 8, 11	Mulberry
Acer rubrum, 10, 11	(Red) maple	Diospyros Virginiana, 5	Persimmon
Quercus **nigra**, 6-8, 11	Water oak	Fraxinus profunda? 10, 11	Ash
		Ilex opaca, 6-8, 11	Holly

SMALL TREES OR LARGE SHRUBS.

Myrica cerifera, 1, 6-8, 10, 11	Myrtle	Crataegus Crus-Galli?	(Red) haw
Crataegus apiifolia, 8, 11	(Parsley) haw	Salix longipes? 1, 10	Willow
Osmanthus Americana, 2, 3, 7, 8		**Ilex Cassine**, 7	
Batodendron **arboreum**, 2, 3, 6-8	Sparkleberry		

WOODY VINES.

Rhus radicans, 8, 10, 11	Poison ivy	**Bignonia crucigera,** 8	Cross-vine
Berchemia scandens, 1, 10, 11	(Rattan vine)	Vitis rotundifolia, 7, 8	Bullace (muscadine)
Decumaria barbara, 10, 11			
Ampelopsis arborea, 10, 11		**Smilax auriculata,** 2, 3, 8	

SHRUBS.

Serenoa serrulata, 2-8	Saw-palmetto	**Cholisma ferruginea,** 2, 3, 5, 7	
		Ilex vomitoria, 8	(Yaupon)
Sabal glabra, 8, 11	Palmetto	**Baccharis halimifolia,** 5	
Viburnum obovatum, 8, 10, 11		Aralia spinosa, 6	Prickly ash
Cornus stricta? 8, 10		Callicarpa Americana, 6-8	French mulberry
Rosa Carolina, 10	Wild rose		
Cephalanthus occidentalis, 1, 10	Elbow-bush	Sageretia minutiflora, 8	
		Aster Carolinianus, 10	

HERBS

Tillandsia usneoides, 2-8, 10, 11	Spanish moss	**Tubiflora Carolinensis,** 8, 11	
Tillandsia tenuifolia, 7, 8, 11	Air-plant	Viola obliqua?	(Blue) violet
Polypodium polypodioides, 7, 8, 11	(A fern)	Oplismenus setarius, 7, 8, 11	(A grass)
Rhynchospora miliacea	(A sedge)	**Scleria triglomerata,** 7, 8	(A sedge)
Mitchella repens, 7, 8, 11	(Turkey-berry, partridge berry)	**Centella repanda,** 1, 4	
Saururus cernuus, 10, 11		Dioscorea villosa?	
Iris **versicolor**		**Epidendrum conopseum?** 7, 8, 10, 11	(An orchid)
		Apios tuberosa	
		Conopholis Americana, 6-8.	

The proportion of evergreens is about 43%, or very nearly the same as in the high hammocks. Ericaceae and Leguminosae are nearly as scarce as in the high hammocks. The proportion of vines is about the same too, fire being equally rare in both types. Nearly all the plants above enumerated can be found in the list of Gulf hammock region plants of northern Florida published in the 6th Annual Report (pp. 304-308), and in approximately the same relative order.

Little use is made of the timber, but the soil is utilized for the cultivation of oranges near Monarch and vegetables near Coleman, as indicated in the chapter on soils.

10. (CALCAREOUS) SWAMPS AND STREAMS.

(FIGURE 69.)

Although Florida probably has more different kinds of swamps than any other state, those in the Ocala area are all so much alike that they can very well be described together. Here they are generally associated with comparatively large bodies of more or less calcareous water, like Lake Panasoffkee, the Withlacoochee River, and the runs of Silver and Blue Springs. (They are indicated as Swamp on both of the accompanying maps.) Branch-swamps, bays, and cypress ponds, such as are common in some of the less calcareous parts of Florida, are rare here.

The swamps are characterized by peaty soil, usually containing considerable calcium carbonate in the form of shells or otherwise, and water which does not fluctuate much. They seem to be underlaid by limestone or marl at no great depth, and they belong to the class of swamps with calcareous water, described in the Third Annual Report (pages 239-240). They intergrade more or less with the low hammocks, which they resemble in aspect. Fire is almost impossible in these swamps, and nothing is known of any subterranean animal life.

The plants of the swamps and marshes near Panasoffkee were enumerated in the 3d Annual Report, page 279. The following list includes all those and some observed along Silver Spring Run and Blue Spring Run in March.

TREES.

Taxodium distichum, 9, 11	Cypress
Acer rubrum, 9, 11	(Red) maple
Fraxinus profunda? 9, 11	Ash
Fraxinus Caroliniana? 9, 11	Ash
Salix longipes? 1, 9	Willow
Fraxinus sp.	Ash
Sabal Palmetto, 7-9, 11	Cabbage palmetto
Liquidambar Styraciflua, 6-9, 11	Sweet gum
Ulmus Floridana, 9, 11	Elm
Pinus Taeda, 6, 8, 11	Short-leaf pine
Magnolia glauca, 4, 9, 11	Bay

WOODY VINES.

Rhus radicans, 8, 9, 11	Poison ivy
Berchemia scandens, 1, 9, 11	(Rattan vine)
Decumaria barbara, 9, 11	
Ampelopsis arborea, 9, 11	

SHRUBS.

Cephalanthus occidentalis, 1, 9	Elbow-bush
Cornus stricta? 8, 9	
Itea Virginica	
Sambucus Canadensis	Elder
Myrica cerifera, 1, 6-9, 11	Myrtle
Aster Carolinianus, 9	
Viburnum obovatum, 8, 9, 11	
Rosa Carolina, 9	Wild rose

HERBS

Tillandsia usneoides, 2-9, 11	Spanish moss
Pistia spathulata	Water-lettuce
Piaropus crassipes	Water-hyacinth
Cicuta Curtissii	
Hydrocotyle Bonariensis	
Sagittaria lancifolia	
Ceratophyllum demersum	(Coon-tail moss)
Eupatorium serotinum	
Rhynchospora corniculata, 1	(A sedge)
Cladium effusum, 1	Saw-grass
Pontederia **cordata, 1**	
Hydrocotyle verticillata	
Carex comosa	(A sedge)
Acnida australis	Careless
Erechthites hieracifolia	
Saururus cernuus, 9, 11	
Nymphaea macrophylla, 1	Bonnets
Lemna sp., 1	(Duckweed)
Osmunda regalis	(A fern)
Hymenocallis sp.	Spider-lily
Scirpus validus	(Bulrush)
Dryopteris Thelypteris	(A fern)
Echinochloa Crus-Galli?	(A grass)
Carex alata?	(A sedge)
Epidendrum conopseum? 7-9, 11	(An orchid)
Carex stipata?	(A sedge)
Rumex sp.	(Dock)
Mikania scandens	
Sagittaria natans?	

Not over 10% of the woody plants are evergreen, which is a remarkably low figure for central Florida. The proportion of evergreens is evidently considerably larger among the herbs, although there are doubtless a good many species which die down in winter and are not recognizable in the spring, and if these swamps could be studied in the fall the apparent proportion of evergreen herbs would be reduced. But the difference in the figures for trees and herbs is probably due to the fact that the trees send their roots down into the rich marl substratum, while some of the herbs are air-plants, several are floating aquatics, not attached to the soil, and most of the rest draw their sustenance chiefly from the peat, which is notoriously deficient in potash, the world over. Ericaceae and Leguminosae seem to be entirely absent, probably for the same reasons that they are scarce in the high and low hammocks.

II. SHORT-LEAF PINE AND CABBAGE PALMETTO BOTTOMS.

(FIGURE 70.)

In the extreme eastern part of the Ocala area, within a few miles of Silver Springs, is a peculiar type of vegetation in which short-leaf pine and cabbage palmetto are the dominant trees. It corresponds approximately with the "Dead River swamp" of the old topographic base map, and the "Fellowship clay" and part of the "Fellowship sandy loam" and "Swamp" of the soil map; and might be regarded as an old flood-plain of the Ocklawaha River, at the western edge of the lake region.

The soil varies considerably in texture and moisture, but is mostly flat and damp, rather clayey, but not noticeably rocky or calcareous. No mechanical or chemical analyses of it are available. (There is a mechanical analysis of "Fellowship sandy loam" in the chapter on soils, but that is a composite of three samples, two of which seem to represent open flatwoods and high pine land.) The wetter parts look much like some of the low hammocks and swamps already described, and the drier parts pass gradually into open pine woods a few miles northeast of Silver Springs. Soil animals have not been noticed, but are probably not entirely wanting. Fire must be very rare, as in other damp shady forests.

The following plants were observed northeast of Silver Springs in March and southeast of there in July.

TREES.

Pinus Taeda, 6, 8, 10	Short-leaf pine	Fraxinus profunda? 9, 10	Ash
Sabal Palmetto, 7-10	Cabbage palmetto	Crataegus viridis	(Red) haw
Taxodium distichum, 9, 10	Cypress	Ulmus Floridana, 9, 10	Elm
Liquidambar Styraciflua, 6-10	Sweet gum	**Magnolia glauca,** 4, 9, 10	Bay
Quercus **nigra,** 6-9	Water oak	Nyssa biflora	Black gum
Fraxinus Caroliniana, 9, 10	Ash	Ulmus alata, 8	Elm
Quercus Michauxii, 8	White oak	Hicoria aquatica	(Swamp) hickory
Acer rubrum, 9, 10	(Red) maple	Morus rubra, 8, 9	Mulberry
Carpinus Caroliniana, 8, 9	Ironwood	**Ilex opaca,** 6-9	Holly
Quercus **hybrida?** 9	(Water oak?)	Acer Negundo, 8	(Box elder)

SMALL TREES AND SHRUBS.

Myrica cerifera, 1, 6-10	Myrtle	Viburnum obovatum, 8-10	
Sabal glabra, 8, 9	Palmetto		
Crataegus apiifolia, 8, 9	(Parsley) haw		

WOODY VINES.

Ampelopsis arborea, 9, 10		Parthenocissus quinquefolia, 6, 8	Virginia creeper
Rhus radicans, 8-10	Poison ivy	Vitis aestivalis? 7, 8	Wild grape
Berchemia scandens, 1, 9 10	(Rattan vine)	Smilax **rotundifolia?** 8	
Decumaria barbara, 9, 10			
Tecoma radicans	(Cow-itch)		

HERBS.

Tillandsia usneoides, 2-10	Spanish moss	**Tubiflora Carolinensis,** 8, 9	
Saururus cernuus, 9, 10		**Epidendrum conopseum,** 7-10	(An orchid)
Tillandsia tenuifolia, 7-9	Air-plant	**Mitchella repens,** 7-9	(Turkey-berry, partridge berry)
Polypodium polypodioides, 7-9	(A fern)	Dichondra Carolinensis	
Dryopteris patens? 8	(A fern)		
Oplismenus setarius, 7-9	(A grass)		

This is one of the few vegetation types in which the trees outnumber the herbs. Vines are fairly abundant. The proportion of evergreens is about 40%, not very different from that of the high and low hammocks. No Ericaceae or Leguminosae appear in the list. The most striking feature of the vegetation is the abundance of short-leaf pine, for there is very little of it elsewhere in this area, or anywhere farther south.* A good deal of it, as of the cypress, has been cut for lumber, but little use has yet been made of any of the other plants, or of the soil.

12. CLAYEY PINE WOODS OR OPEN FLATWOODS.

In the extreme northeastern corner of our area and beyond, on "Fellowship sandy loam," are open long-leaf pine forests with nearly level topography and grayish clayey soil (at least clayey in comparison with the average soil of central Florida), something unusual for peninsular Florida, but suggesting the "pine meadows" of southern Mississippi.*

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*Its distribution in Florida and elsewhere corresponds roughly with that of the cotton crop, and Marion is one of the southernmost counties in which any cotton is raised.

As far as the aspect of the vegetation is concerned, it differs from the high pine land in the scarcity of oaks, and from the palmetto flatwoods in the scarcity of saw-palmetto and other bushes. The undergrowth is mostly wire-grass. With increasing moisture and humus it passes gradually into the short-leaf pine and palmetto forests just described. As the writer has seen this vegetation only from the train, and the area of it within the limits of this report is very small, no satisfactory list of plants can be given at this time.

The long-leaf pine yields lumber and naval stores, as usual, and many cattle are grazing on the wire-grass. Some vegetables have been raised on this kind of land around the new town of Burbank, a few miles northeast of Silver Spring, a little outside of the area mapped.

SUMMARY AND CONCLUSIONS.

The "Ocala area" includes parts of five geographical regions, and its vegetation comprises about a dozen characteristic types, all of which intergrade more or less.† The soil represents very nearly the extremes of sterility and fertility, with many intermediate conditions, and the vegetation is pretty closely correlated with it. The poorest soils are easily recognized by their high proportion of evergreens and Ericaceae, and *vice versa*. (Although we have not enough chemical analyses of soils from this particular area to warrant positive assertions, evidence gathered elsewhere points to the conclusion that evergreens have little use for potassium and Ericaceae for calcium.)

Leguminous plants are scarce both in the poorest soils and in those with abundant humus, and seem to prefer dry but moderately rich soils.

Some very dissimilar types of vegetation with similar soils are differentiated by different frequencies of fire. Fire originating by natural causes has had a profound influence on vegetation in this part of the world, and it is much more frequent in some types than in others, depending on the location with respect to bodies of water, etc., and also on the character of the vegetation itself, especially the amount of grass and of humus. Where fire is rarest woody vines are most abundant, and *vice versa*.

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*See Bull. Torrey Bot. Club 41:555-556. 1914.

†In taxonomic studies of plants and animals intergradation has commonly been regarded as an indication of specific identity. But in studies of soils and vegetation it is necessary, or at least expedient, to recognize a number of pronounced tendencies, or extremes, regardless of intermediate conditions; and the same principles ought to apply in systematic botany and zoology also.

Some of the relationships between the different vegetation types have already been pointed out in the descriptions. They can also be illustrated graphically and more concisely by diagrams or tables. Some plant sociologists have constructed diagrams in which all the different vegetation types or plant associations of a given area are connected by arrows showing the supposed direction of succession, i. e., the tendency of one type of vegetation to encroach on another. Although it is reasonable to conclude that of the vegetation types here described the sandy hammocks are tending to encroach on the scrub wherever the two are in contact, and would encroach on the high pine land if the frequency of fire was diminished, and the high hammocks may be slowly invading the red oak territory, we have little or no evidence of any other tendencies to succession in this area. Most of the types of vegetation are pretty closely correlated with soil and topography, and can hardly be expected to supersede one another without changes in soil or topography, and those take place so slowly that we cannot detect them. The vegetation is therefore practically in a state of equilibrium (except for the interference of man, which is not taken into account here).

The geographical (or more strictly speaking, chorographical) relations between the various types are shown by the vegetation map. Naturally there can be no successional relation between types which are nowhere contiguous, such as flatwoods and red oak woods.

The floristic relationships can be best exhibited perhaps by statistics showing how many species any two types have in common, not in absolute figures but in "coefficients of community." The coefficient of community between any two floras, or lists of plants, is the ratio of the species common to the two to the total number in the two taken together,* and is usually expressed as a percentage. The following table shows the percentage coefficients of community between all the vegetation types herein described, except the last, whose plants are not listed. One serious drawback of the scheme is that no account is taken of relative abundance; but there seems to be no easy way to remedy that. The figures must be regarded as only approximate, for they are liable to be modified by additional field work and the inclusion of rarer species. If woody plants and herbs were handled separately no doubt some important differences between them would be brought out, but that seemed a little too much of an undertaking for the present.

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*See Harshberger, Trans. Wagner Free Inst. Sci. 7:185-186. 1914. The total number of species in two areas is of course not the sum of the two taken singly, but that sum minus the number common to both.

Coefficients of community for II *vegetation types of the Ocala area.*

	2	3	4	5	6	7	8	9	10	11
1. Lakes, ponds prairies	1.8	1.6	11.2	0.7	1.1	2.4	0.8	5.2	11.0	2.5
2. Scrub thickets		48.1	13.3	7.0	10.7	20.0	6.4	8.1	1.4	1.7
3. Scrub			9.0	6.7	8.3	20.7	5.0	6.3	1.4	1.6
4. Palmetto flatwoods				10.7	12.0	5.4	3.2	3.7	2.0	2.2
5. High pine land					14.7	4.8	3.3	3.1	0.6	0.7
6. Red oak woods						21.3	22.5	9.4	4.4	9.0
7. Sandy hammocks							32.6	23.6	5.0	15.4
8. High hammocks								29.7	7.2	26.5
9. Low hammocks									23.9	38.7
10. Swamps										23.7
11. Short-leaf pine and palmetto										

It will be noticed that the coefficient is generally greatest between consecutive types (which indicates that the sequence here adopted is a logical one), but in no case exceeds 50% (which indicates that the distinctions are fairly well founded*). It happens that every two types in the table have at least one species in common, and that the coefficient falls below 1% in only four cases, and those are where upland and lowland vegetation are contrasted.

If we add together the 11 coefficients for each type we will be led to the conclusion that No. 1 is the most distinct of all, No. 5 next, and No. 4 next, while No. 9 is the least distinct, No. 7 next, and No. 8 next. The significance of this is not quite clear, but it is noteworthy that the three first mentioned are all open types of vegetation, with many herbs, while the other three are dense and shady, with few herbs.

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*It should be borne in mind, however, that floristic distinctness is not essential for the discrimination of vegetation types, for two types might contain exactly the same species, but in such different proportions as to appear very different. (See 6th Annual Report, p. 175, footnote.) And on the other hand it might be possible to select small areas in the same vegetation type which have few or no species in common.

The 11 plant lists together contain 128 species of woody plants and 187 of herbs, which is probably about four-fifths as many woody plants and one-third as many herbs as could be found in the same area by a thorough search. Sixty per cent of them appear in only one list each, 20% in two, 10% in three, 5.5% in four, 2.5% in five, 1.3% in six, and 1% in more than six. The average species is common to 1.8 of the vegetation types as here defined. But the average woody plant is much less particular about habitats than the average herb, for woody plants have an average distribution through 2.4 types and herbs only 1.4. (If the rarer herbs were included the last figure would be still smaller.) This seems to indicate that the herbs are more sensitive to minor variations of soil, illumination, etc., than the trees and shrubs are, which is just what we should expect.

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SOIL SURVEY OF THE OCALA AREA, FLORIDA.

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DESCRIPTION OF THE AREA.

The Ocala area is situated in the north-central part of the Florida Peninsula, approximately midway between Jacksonville and Tampa. From the Gulf of Mexico the western boundary is distant about 15 miles, while the eastern boundary is approximately 60 miles from the Atlantic coast. The area is rectangular in shape, about 35 miles long north and south and 30 miles wide east and west.

Topographic sheets were made of this section some years ago by the United States Geological Survey. These were used as the base for mapping the soils, such changes as were necessary to bring the road systems in accord with existing conditions being made.

The survey comprises an area, inclusive of the bodies of water, of about 1,002 square miles, or 641,280 acres. It covers parts of Marion, Sumter, Citrus, and Levy Counties, about half the area mapped being in Marion County.

The peninsula of Florida lies in the physiographic province known as the Coastal Plain. Roughly, the peninsula consists on either coast of a generally flat coastal country, only slightly elevated above sea level, with an elevated region extending down through the center, the elevation attained being 200 or more feet on the highest points. This elevated region is spoken of as the backbone of the peninsula and has been held up by the underlying rock beds. The Ocala area is situated in this elevated region and has a varied topography ranging from flat areas, known as "flatwoods," to rolling areas and high "hammocks." The general elevation ranges from 40 feet above sea level in some of the stream valleys to 220 feet in the western part of the area.

This part of Florida is underlain by limestone at no great depth; in fact, in places it outcrops at the surface. In the geologic past the region, while elevated, was subjected to erosion, resulting in an irregular surface. In addition, the limestone, being more or less soluble, was dissolved in places, forming subterranean caverns, which in falling in gave rise to sinks and large basins, further modifying the surface. Then, with a period of submergence, there was a deposition of sedimentary materials (mostly marine) over this irregular surface, and their emergence followed in time, attended, no doubt, by minor changes in the surface by erosion. The sinks and basins remained and as the solution of the limestone has continued these have enlarged to form ponds and lakes, and even new sinks are forming at the present time.

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In detail the Ocala area consists largely of rolling and low, hilly country, intersected by the Withlacoochee River, with its low, flat areas and swamps, and by Tsala Apopka Lake. Coming in at the north-central boundary of the area is a body of high hammock land belonging to the "middle hammock belt" described in the State geological reports. It consists of irregular bodies of low hills, ranging from 90 to 180 feet above sea level, the tops of which are rounded to flat, with some depressed basins and rather smooth, long slopes having numerous eroded draws or ravines occupied by small streams which empty into sinks on the bottom of the slopes.

These areas of hammock land are not continuous, occurring as scattered islandlike bodies in the rolling sand areas of the country. They occur in the area in Marion and Sumter Counties, the largest being around Ocala, and are upheld by underlying rock formations. The greater part of the area is occupied by what is known as the "rolling pine lands." These lands comprise country of irregularly distributed elevations and depressions, largely the result of the great number of sink depressions caused by the solution of the underlying limestone. The result is a choppy topography, which here and there flattens out to gently undulating. A gently undulating belt follows that of the high hammocks, the change in elevation being only 10 to 20 feet and averaging about 80 feet above the sea level. To the west the rolling sandy lands become much more choppy and higher, and east and north of the Withlacoochee River attain elevations of 120 feet on the higher points, with some on the western border north of Dunnellon reaching 150 feet above sea level. South and west of the Withlacoochee the surface is very broken, being marked by large and deep depressions, the bottoms of which lie from 10 to 40 feet above sea level, while the summits of the surrounding hills attain a height of 150 to 220 feet above sea level.

Cutting through this rolling country is a broad belt of low, flat country extending from a few miles east of Dunnellon southeast out of the area. The Withlacoochee River flows through it and it may be termed the valley of this river. Associated with it is Lake Panasoffkee on the east and Lake Tsala Apopka on the west. This is a section of low-lying flatwoods, interspersed with prairie ponds, low hammocks of semiswampy character, and cypress swamps. The average elevation of this section is between 40 and 50 feet above sea level, with a few higher elevations. In appearance and condition Lake Tsala Apopka resembles the Everglades. It consists mostly of shallow water, with a thick growth of saw grass, interspersed with open, deeper bodies of water and with areas of land having a characteristic growth of scrub saw palmetto and stunted pines and lying but slightly above the elevation of the lake. There are some land areas supporting a "hammock" growth, and also cypress "bays" here and there. In the latter the tallest cypress trees are in the center, the trees gradually decreasing in size toward the edge in such a way that they stand out on the sky line in triangular or pyramidal form with the apex near the center. There are also some sandy islands that rise as high as 20 feet above the water. The descent into all this low-lying region from the adjacent rolling lands is rather abrupt.

In the northeast section of the area there is another low-lying strip of hammock flatwoods and swamp following Silver Springs Run, which is a part of the Ocklawaha River Valley, lying just outside of the area. Again, just west of Dunnellon a flatwoods area begins and extends west out of the area. This is evidently a part of the low coastal country reaching to the Gulf.

Aside from the large streams there are strikingly few streams in the area. The exceptions are the small branches following down the draws on the slopes of the high "clay hammocks." These flow intermittently as a rule and soon disappear into sinkhole ponds. The water falling upon the surface either seeps into the sinks and swamps or percolates downward through the porous sand into the underlying porous limestone, finally reaching subterranean channels. Some of these subterranean streams come to the surface, as strikingly illustrated by Silver Springs in the eastern part of the area and Blue Spring in the western part. These "springs" discharge a large quantity of water, the seasonal variations of the volume being very little. There are also a number of smaller springs in the low hammocks and swamps.

A part of the drainage waters reaches the Atlantic Ocean by way of the Ocklawaha and St. Johns Rivers. Silver Springs Run is the main source of supply of the former. The run and the river are both navigable streams, and are used for passenger and freight boats. The Withlacoochee River is of considerable size, rising some distance to the south of the area. It flows in a northwest direction through the area. A part of it is navigable.

Settlement within the area surveyed followed some years after that of Alachua County, in which settlement was begun in 1825. The early settlers came originally from the Carolinas and Georgia, and immigration from these States has continued even to the present time. In the last few years there has been some immigration of people from the Northern, Western, and Southern States, attracted by the mild climate and the agricultural possibilities of this as well as of all other sections of the State. The present population is thus an aggregation of the native stock of the State and of the different States of the Union. There is also a large negro population scattered throughout the counties represented in the survey. Marion County is one of the largest in the State and has a population of 26,941, according to the Thirteenth Census. Levy, another large county in areal extent, has 10,361 inhabitants, and Sumter and Citrus, much smaller counties, have, respectively, 6,696 and 6,731.

Ocala, the county seat of Marion County, is the largest place, having a population of 4,370 within its corporate limits in 1910. It is an important railroad center and a prosperous business town, its business interests reaching into the adjoining counties. Its banking business extends to all the industries of the section, including phosphate mining, lumbering, turpentining, and agriculture.

In the western part of the area surveyed, on the Atlantic Coast Line Railroad, are the towns of Dunnellon, Hernando, Holder, and Inverness. They are in the phosphate mining district, and their inhabitants are largely engaged in this industry.

On the Seaboard Air Line Railway, in the eastern part of the area, are the towns of Belleview, Summerfield, Oxford, Wildwood, and Coleman. Their interests are entirely agricultural. In addition there are a number of smaller places on the different railroad lines that are shipping points for forest and farm products.

The railroad facilities of the area surveyed are exceptionally good. Main lines of the Seaboard Air Line and Atlantic Coast Line traverse the area from north to south, with some smaller branch lines of each road. These give good transportation facilities for both passengers and freight to both North and South. In addition, there are two new roads, the Ocala Northern, extending from Ocala to Palatka, giving a short route to the east coast, and the Ocala & Southwestern, reaching into the central part of the area from Ocala and Martel. There are also some logging railroads that are expected to be made permanent.

The county roads are fast being improved to meet the present and future needs. A considerable mileage of clay surface or stone roads reaches out of Ocala in every direction. There is also a stone surface road connecting Dunnellon and Inverness. The making of hard roads is being extended, and they are planned to form parts of the important highways of the State.

The general farm products meet with a ready sale in the surrounding towns, and, in fact, there is not enough produced to supply the local demands, so that a large quantity is shipped in. Large quantities of grain and hay are shipped in to feed the working stock. The truck and citrus-fruit crops are shipped to northern markets and lumber and turpentine are sent to outside markets for these products. Most of the phosphate rock mined in the area is exported to foreign countries.

CLIMATE.

No extended climatological records have been kept within this area. Observations for short periods have been made at Ocala, Rockwell, and Inverness, but not long enough to obtain normals. The longest records available are those for Archer, which lies some distance away in the adjoining county to the north. The data given in the following tables have been taken from the Weather Bureau records for that station. The tables give the normal monthly, seasonal, and annual temperature and precipitation. These figures vary but little from those for the stations within the area for the short period the latter have been taken, and so may be taken as fairly representative of local conditions.

Normal monthly, seasonal, and annual temperature and precipitation at Archer and Ocala.

MONTH	ARCHER						OCALA.	
	Temperature			Precipitation				
	Mean.	Absolute maximum.	Absolute minimum.	Mean.	Total amount for the driest year.	Total amount for the wettest year.	Temperature.	Precipitation.
	Deg. F.	Deg. F.	Deg. F.	Inches	Inches	Inches	Deg. F.	Inches
December	57	89	13	3.3	1.6	5.6	58.0	2.37
January	55	84	17	3.2	5.0	8.2	57.4	2.73
February	59	90	10	3.9	3.8	6.9	59.6	3.19
Winter	57			10.4	10.4	20.7	58.3	8.29
March	63	94	24	4.1	0.8	3.8	65.3	2.89
April	68	94	33	2.7	2.0	0.3	69.4	2.01
May	75	101	46	3.9	0.8	6.6	75.5	3.38
Spring	69			10.7	3.6	10.7	70.1	8.28
June	80	101	55	7.1	7.2	11.4	79.7	7.69
July	81	101	59	8.4	6.4	5.9	81.4	8.19
August	82	99	59	7.3	7.8	10.2	81.2	7.54
Summer	81			22.8	21.4	27.5	80.8	23.42
September	79	98	48	6.1	3.6	11.6	78.7	7.35
October	71	94	32	2.6	2.0	4.8	72.0	2.69
November	63	88	20	2.3	0.6	1.4	64.2	1.61
Fall	71			11.0	6.2	17.8	71.6	11.65
Year	69	101	10	54.9	41.6	76.7	70.2	51.64

The climate is mild and agreeable, the mean annual temperature being 69° F. It approaches that of the subtropics. The summers are not regarded as excessively hot, as they are tempered by practically constant winds. The only discomfort is that brought on by long-continued uniform heat. The temperatures occasionally hover around the hundred mark and maximum temperatures of 101° F. have been recorded in May, June, and July. The normal seasonal summer temperature is 81° F. The spring and fall seasonal means vary little from each other, the former being 69° and the latter 71°.

The winters are mild and generally pleasant, there being occasional cool spells of a few days when the temperature goes slightly below the freezing point. Lower temperatures have occurred, but are infrequent; a minimum of 10° F. above zero at Archer has been recorded. The possibility of such extremes makes the growing of citrus fruits risky, but the danger is now being met by the use of oil smudge pots or open fires in the groves.

The mean annual precipitation at Archer, as shown by the table, is 54.9 inches. At Ocala the mean for 16 years is 51.64 inches. At Rockwell for a period of nine years it is 52.55 inches, and at Inverness 51.74 inches. This rainfall is not evenly distributed, the greater part falling during the summer months. A wet and a dry season are recognized, the summer being the wet season, while the winter is looked upon as the dry season. There are really two periods of each. The wettest season extends through June, July, August, and a part of September. This is followed by a comparatively dry season, beginning the latter part of September and extending through October, November and December. There is then a short season of good rainfall in January and February, followed by the driest part of the year in March, April and May. The summer rains are torrential and of tropical character, occurring mostly in the afternoon and rarely at night, the clouds usually disappearing by sunset. As shown by the table, there is considerable range in precipitation from year to year, there being a difference of 35 inches between the wettest and driest years. Since the so-called dry season occurs in winter and spring, when the rainfall is moderate and irregular and periods of drought are frequent, trucking is often seriously affected, so that irrigation is essential for the greatest measure of success. Some irrigation is practiced, the overhead system being used. As the elevation is too high for artesian flow, the water must be pumped.

On an average there is no danger from frost for about 9 months of the year, but the growing season is very often extended beyond this. Winters occur when there is comparatively little frost and this restricted to a short period. January and February are the months during which frosts are to be expected.

Cabbage is the only trucking crop grown during the winter. Most of the other truck crops are planted in February. In the case of tomatoes the seed are dropped in the row and thinned for stand. In a couple of weeks seed are dropped in between, so that if frost occurs the second planting will come on, and often even a third planting is made in order to insure a crop.

As the area lies inland, the winters are somewhat colder than along the coast and the summers warmer. This difference amounts at times to several degrees. The citrus groves are located as near the bodies of water as possible, experience having shown the modifying influence of even small water areas where the minimum temperature lies normally so near the limit of safety.

While the bodies of water are not such as to make the region attractive as winter resorts, increasing numbers of winter tourists are coming to the region, the eastern boundary of the area touching what is known as the lake region of the State.

AGRICULTURE.

The extension of settlement within the area surveyed took place slowly, and its population was until recently confined to a few communities. The early agricultural operations were not extensive and farming was mainly of a self-sustaining type, markets being remote. Corn, rice, sweet potatoes, and sugar cane were grown for home consumption. Soon, however, the growing of sea-island cotton was begun. This could be marketed by water and was the main source of income. Though the growing of sea-island cotton assumed considerable importance in central Florida, it only reached into a small part of this area on the hammock lands in the central part of Marion County. After a time, it is reported, the "caterpillar" became a great pest, and the growing of cotton was partly abandoned, but in recent years, owing to the lack of labor for more intensive farming, the growing of this staple has been extended. Particularly profitable was the crop following the Civil War, when cotton prices were very high.

Stock raising was also taken up in the early days. Practically all the country was an open range, and stock could graze over large areas. The prairie "ponds" afforded good pasturage at certain seasons, and there was also pasturage on the higher lands. In the swamps and low hammocks there was good grazing for cattle and plenty of mast for the hogs, so that both thrived. Cattle raising finally attained much importance, becoming the sole occupation of many, and it has remained a leading industry to the present time. The cattle, however, were not of the best, as they received no care, and during the winter season many starved for lack of sufficient food. Even with the great losses entailed, good profits were obtained, because of the fine range, the stock raisers being under no expense beyond looking after and marketing their stock.

In 1859 an orange grove was started at Micanopy, in the county north of Marion, by budding the sweet orange on the sour wild-orange stock. This venture proved successful and the growing of citrus fruits soon extended, as the fruit met with a ready demand. The soil and climate were suited to the growing of citrus fruits and the industry rapidly developed, suitable lands being in great demand and bringing good prices. In the late eighties the lands were greatly exploited for citrus fruit growing and a land boom was started, values rising rapidly. Even the high sandy lands, considered of little value, were put on the market and brought high prices. Then, in 1888, hard phosphate rock was discovered and exaggerated views were held as to its extent and value. This, together with the exploiting of land for citrus fruit growing, caused the wildest speculation to ensue. Towns were laid out in this area and lots brought high prices, but as these lots were bought by people remote from the section and for speculation, the building of the towns did not follow. These abnormal conditions could not last long and the boom necessarily collapsed, the reaction causing a great depression throughout the section, which affected agriculture especially.

Agriculture met with another reverse a few years later, when during the freeze of 1894-95 all the orange trees in this section were killed to the ground. With few exceptions, this practically ended the growing of fruit in the area. Prior to the freeze every home had its orange grove, which yielded a fair income. In fact, dependence was placed mostly on the orange grove and the stock on the range and little effort was put forth to cultivate the land beyond the growing of subsistence crops. After the freeze lands were abandoned and forfeited to the State for nonpayment of taxes. The value of the lands fell to almost nothing. Some of the best hammock lands up to 1900 could be bought for a mere trifle. This freeze caused temporarily the greatest setback that agriculture has had in the section. There have been other freezes, but none that were so widespread or so severe.

Along in the nineties the turpentine industry began and grew rapidly. A small income was derived from this source, as previously the trees had very little value, lumbering not having reached this section. However, the saw mill soon followed and began cutting into the pine forests. The prices paid for the privilege of turpentining were small as compared with those paid now. Two or three cents a box was formerly a good price, and it has gradually risen, as the working area has decreased, to 15 cents or more a box.

In the county north of the area surveyed trucking, which had been taken up to some extent before the freeze, was greatly extended afterwards and was fostered by the extension of railroads into the region. The trucking industry, however, did not develop in this section, at least not to any marked extent. A notable exception was the beginning of trucking in Sumter County, near what is now Coleman, in the Warm Spring hammock, where the growing of cabbage for market was begun. This was about 1888. This hammock was found especially suited to the growing of this crop, the production of which attained considerable importance, and has continued without interruption to the present time. In this same hammock there was also a large orange grove, which was killed during the freeze of 1894-95.

The area of hammock lands being small, and other soils, as the sandy ones, being held in low esteem, the growth of agriculture was retarded, and even the areas cultivated were not made as productive as they should have been, so that the agricultural resources of this section have hardly begun to be developed. The interests within the area are varied. The western part, which is in the belt where the hard-rock phosphate is found, is devoted entirely to the mining of phosphate rock, no attention being given to agriculture, partly because of the undesirability of the land for farming purposes. Turpentining is still an important industry and large quantities of turpentine and rosin are produced. The sawmills still have considerable forest to work upon, and there is a great deal of interest in this industry. Cattle and hogs are raised in considerable numbers and still roam at will over the open range, but this is being restricted gradually by owners fencing in their holdings. Stock raising remains profitable because the stockman is still at no expense to get his cattle ready for market. With the growing population, beef and pork find good home markets, the production of pork not being sufficient to fill the demand. Some cattle are shipped out to southern cities. While many of the cattle are of poor grade, owing to the manner in which they are raised, they are suited to the conditions they must endure. Some improvement is being brought about by the introduction of pure-blooded sires of improved breeds, particularly the Jersey and the Hereford, but it is not general. Some herds have been improved greatly. Hogs are receiving considerable attention, and the razorback is gradually being displaced by better stock.

During the last two or three years the cultivated areas of farms have been greatly increased. The agriculture of the area consists of growing the general farm crops along with heavy trucking, in which a large acreage is usually involved. The general farm crops follow the truck crops, the latter being heavily fertilized, and the following crop, such as corn, getting the benefit of the fertilizer remaining in the soil. Thus, corn always succeeds crops that are marketed early, such as cabbage, tomatoes, and snap beans. Besides corn, the velvet bean is an important field crop. This plant matures its seed in this section and is sold for seed. The light sandy soils of the Norfolk series will grow the velvet bean and improve in productiveness at the same time. The crop is grown alone or with corn. It is said to do better with corn, as where it covers the entire ground the growth is so rank that it smothers itself. Ten bushels or more per acre is considered a good yield, and 15 to 20 bushels are often obtained. Oats are grown to some extent, being cut when in the heading stage and cured for hay. Peanuts are grown extensively, especially on the lighter soils. These are grown between the rows of corn, and while much of the crop is intended for feeding hogs, a considerable proportion is harvested and put on the market. In 1909, according to the Thirteenth Census, there were 5,046 acres in peanuts, yielding 88,958 bushels. The peanut, aside from its value as a certain crop, is desirable as a soil improver.

Sugar cane is grown on every farm, but few produce more than enough to make sirup for domestic use. The product, which is being manufactured by the open-kettle process, is of excellent quality. About 15 to 20 barrels of sirup to the acre can be made. A number of varieties of sugar cane are grown, but the Japanese cane is much in favor and makes a good forage crop, as well as an excellent grade of sirup. Cowpeas are grown quite generally for hay. A source of hay is the crab grass, crowfoot, sandspur, and beggarweed, which appear as volunteer growths following all cultivated crops. They make a fairly good growth and quantities of hay of this class are usually obtained each year by all the farmers.

Sweet potatoes succeed on all the light soils and are grown universally, but in no large acreages, the output being hardly sufficient to supply the local market demands.

Trucking is now assuming a place of considerable importance. Especially has the industry developed during the last few years. The crops are those that come under the class of heavy truck and are grown in large acreages, though recent purchasers of small acreages of land are entering to some extent into trucking. The crops grown are watermelons, cantaloupes, cucumbers, snap beans, cabbage, and tomatoes, with some egg plants, peppers, and beets.

With the exception of watermelons, trucking is confined to the hammocks around Ocala and those along the Seaboard Air Line Railway from Belleview south, Summerfield and Oxford being trucking centers, as well as Coleman, lower down.

Watermelons are grown in large acreages, and, being a heavy crop, they are confined to sections near railroads. The logging roads reaching into the central part of the area in the areas of light sandy soils, the Norfolk sand and the Norfolk fine sand, are fostering the growth of this crop and haul the product out to the main trunk railroads. The light soils are especially adapted to watermelons and a fair return is realized. Land for this crop must be highly fertilized. The yield is about one-half carload to the acre. The trouble encountered in growing watermelons is the wilt disease, because of which the crop can not generally be successfully grown a second time on the same land for a period of several years. Several varieties are grown, those for market including the Kolb Gem, Big Blue, and Tom Watson. The crop is planted in hills, generally 6 by 9 to 9 by 9 feet apart. The crop is fertilized, using from 500 to 1,200 pounds to the acre of a high-grade special brand. Newly cleared sandy pine land is preferred. The Gainesville loamy sand is also used for the crop and gives somewhat higher yields than the lighter sandy soils.

Cantaloupes are grown quite extensively, but on account of diseases the acreage planted to the crop the past season is said to have been reduced. The Rocky Ford is the only variety grown, the seed being obtained every season from the Rocky Ford district of Colorado. The Gainesville loamy sand and the Gainesville sandy loam are the most desirable soils for this crop, though the better phases of the Norfolk sand at present are also used. The finer textured Gainesville type would also be adapted to their production. About 100 crates is considered a good yield per acre, with an application of 600 to 700 pounds of a fertilizer mixture analyzing about 7-3-4. Experiments are in progress by the Department of Agriculture in this area to demonstrate the methods of fighting the diseases of these and other truck crops.

Cucumbers are grown to some extent. The White Spine is the variety planted. The Gainesville soils are suited to this crop, also the lower-lying, well drained Portsmouth soils and the better phases of the Leon and Norfolk soils. They receive heavy applications of commercial fertilizers and generally yield some profit to the growers.

Cabbage, as stated previously in this report, was the first truck crop grown and shipped out of the area. The high yield and quality of the cabbage, as well as of tomatoes, grown in the Warm Spring hammock at Coleman have made this section widely known. All the heavier soils, especially those having a calcareous or marly subsoil, are desirable for cabbage. This crop also succeeds well on areas of Gainesville sandy loam, having shallow surface soil. In this area the Parkwood and Fellowship series of soils are best adapted to this crop, and its production is mainly confined to these soils. The crop is transplanted to the fields from the middle of September to January, the early cuttings being made for the Christmas market and later ones in April. It is usually planned to put about 11,000 plants on an acre and an average yield of about 250 crates is expected, but the range is considerable, as high as 440 crates to the acre having been obtained at Coleman. On the lighter soils the yield is somewhat lower, but the quality is good. A crate averages about 110 pounds and the average cabbage about 3 pounds. The crop is heavily fertilized on all soils, even on those that are considered rich, such as the calcareous or marly hammocks. At Coleman from 1,000 to 1,500 pounds per acre of a 5-6-8 fertilizer is generally used, but the relative proportions of the different elements vary in different brands. Some claim that 5 per cent of potash is sufficient on the marly lands, but for tomatoes 8 to 10 per cent of potash is better. Cottonseed meal mixtures are used generally and where any crop needs forcing an application of nitrate of soda is given. A number of varieties of cabbage are grown. The flat heads are more in favor than the pointed heads of the Wakefield type, as it is claimed they make larger yields. Market Garden No. 2 is most favored. It makes a flat, firm head and is a sure header. Henderson's Succession and Allhead Early are also planted. The growers of cabbage and tomatoes in the Warm Spring hammock have made profits consistently and are in good financial condition as a whole. The holdings are small; 10 acres is considered enough. Some of the growers have installed overhead irrigation plants. While this is expensive, it makes the production of a crop more certain, as the winters are the dry season of the year and water is generally needed. There is plenty of land that could be utilized for this crop.

There is a considerable production of tomatoes in the area. The tomatoes grown at Coleman, in the Warm Spring hammock, find favor on the market. The fruit is heavy and firm and is said to bring fully 50 cents a crate more than the average market price. The Globe variety is grown exclusively, having been found more resistant to diseases than other varieties, as well as making good yields. The Stone tomato used to be grown, but not being as resistant to disease, poor results were often obtained. The same grade of fertilizer is used for tomatoes as for cabbage, about 1,000 pounds per acre being applied, although, as stated before, this crop needs more potash than does cabbage. About 200 to 300 crates to the acre are considered a good yield.

Snap beans are an important crop and are grown in large acreages. They grow well on the Gainesville types of soil, on the better phases of the Norfolk, and on the sandy types of the Fellowship series on the high hammocks.

Some eggplants and peppers are grown, but these are not important crops in the area surveyed.

Before the freeze of 1894-95 the area surveyed was within the citrus-fruit belt of the State. There were groves on every place, and many put their dependence solely upon the products. Along the Withlacoochee River there was considerable interest in orange culture, and there were many large groves. These were all killed and practically all abandoned, the people even moving out. Citrus-fruit growers then moved farther south, but a few large growers have reestablished their groves. Citrus-fruit growing is now confined to some important groves around Lake Panasoffkee and to a low hammock southwest of Wildwood. This hammock is in one grove of over 500 acres, which is one of the largest in the United States. The freeze of February, 1899, did considerable damage. The trees are young and small and have not yet reached their full bearing capacity, but are just beginning to yield some profit. The low hammocks surrounded by swamps are preferred, the swamps and the large trees left standing in the groves being depended upon for protection. The marl hammocks are most desired, and on these fertilizers are not used. On these low situations the trees are planted on mounds, so that they will be out of the water during wet periods. There is also less trouble from insect pests in these locations, especially where the groves are isolated from other groves. However, insect pests and diseases have to be fought and controlled by spraying. The Pineapple orange is one of the favorite varieties. The King and Harts Tardiff are also important varieties. Some grapefruit and tangerines and a few Satsuma oranges are grown.

Nut culture would probably prove profitable in this area. The pecan will thrive in the climate and soil, and some pecan groves have been started, but have not reached the bearing stage. As far as observed, they are given very little attention.

Crop rotation is not thought of as such, because of the fact that two or three different crops are taken in a season from the same land. The cabbage, for instance, is often grown year after year on the same land, but it is always followed by corn, and after this a crop of crabgrass or beggarweed hay is obtained. Corn follows practically all the trucking crops, receiving benefit from the fertilizers applied to the preceding crop. When a crop is late it is often followed by cowpeas, which are cut for hay. The light, sandy soils, where no trucking is being done, bring only two crops, corn and then crab-grass hay or peanuts and velvet beans, either with or without the corn. A common practice is to let the land lie fallow each alternate year, or rather to let the weeds grow and then plow them under. This benefits the soil, but a better way would be to grow a legume and turn it under.

All engaged in truck growing necessarily follow modern methods and use improved farm implements. There are still in use by some the little 1-horse turning plow and the old type of small, straight plow and sweep rather than the several-toothed cultivators that do so much better work. On newly cleared land, however, these old implements are often all that can be used. With the exception of the heavy hammocks, the soils are all easily cultivated and kept in good tilth.

Fertilizers are applied generally, though where general farming is practiced alone little or none is used. The yields of corn and oats are small. On the truck crops large quantities of high-grade fertilizers are used. Special brands carrying varying proportions of the different ingredients required for particular crops are made by the fertilizer companies represented in this section. These are the cottonseed meal mixtures, and contain some dried blood and tankage as a part of the nitrogen supply. Very few growers mix their own fertilizers. Most of the soils are of a light, sandy character and rather deep, and need constant fertilization. As the quantity of stable manure available is very small, proper soil management must include the growing of crops to be turned under. In no other way can organic matter, in which the soils are mostly deficient, be economically supplied. Even those soils containing considerable organic matter are improved by plowing in some coarse materials. The heavier hammock soils would also be improved by deeper plowing and the turning under of coarse materials. It has been found that the growing of peanuts, cowpeas, and velvet beans on even the lightest soils increases their water-holding capacity and makes them much more productive. An old method of manuring the land, that of "stock penning," is still in vogue. By this method the stock are kept in a small inclosure, an acre or two, and the pen changed when it is thought the soil has been sufficiently enriched. This practice is only followed for a few weeks prior to planting. The practice is good, but more effort should be put forth to make stable manure through the year. A considerable quantity could be produced by keeping the stock corralled at night. At present they are not sheltered.

As is the case throughout the greater part of the State, the rural population of this area is sparse, and only a small proportion of the land is occupied and in farms. There is considerable forested land in this area, and while the turpentine operators and the sawmills have reached all parts, there are yet a considerable number of trees left, which are gradually increasing in value.

The size of the farms is steadily decreasing. In 1880, according to the census figures, the average size of farms was 151 acres; in 1890 it had decreased to 97 acres, and with the division of large areas of land into 10-acre plots during the last few years it must now be still less. There are holdings, however, varying from 5 to 10 acres in the intensive-trucking hammock lands to hundreds of acres, while large tracts of rolling pine land exist upon which no clearings have been made.

While up to recent years the farms have been worked almost entirely by the owners, there is now an increase in lands worked by tenants. The basis of renting varies with the land and conditions, and no general plan is followed. Farm labor has become scarce and commands good wages, almost equal to those for ordinary labor on public works. The labor is mostly negro—men, women, and the larger children being employed.

Land values during the last few years have been steadily rising. New settlers from the North and West are coming in all the time, but these have so far only taken small tracts of colonization companies. Ten acres is the usual size. In case of most of the lands to be acquired in this way the acreage is too small, especially on the light sandy Norfolk soils. On the better hammock lands 10 acres will keep the owner employed, with no need for extra labor except at harvesting time. In small tracts the lands sell for $20 to $30 an acre for the light sandy soils and as high as $50 to $75 for the hammock lands. The latter, however, are not on the market. The pine lands are cleared readily, but the hammocks, with a heavy hardwood growth, are expensive to clear. Large bodies of rolling sandy pine lands and flatwoods with the marketable-size trees removed can be procured at a low price—from $3 to $10 an acre.

The farmers have been realizing good profits the last few seasons and are in a prosperous condition. The banking business in this section is increasing all the time, and a large part of the deposit comes from the farmers. Indications point to an increased development in this section, as the cultivated areas are rapidly being extended. General farming, with trucking, offers good, substantial returns.

By draining the low-lying lands of some of the flatwoods and low hammocks valuable trucking soils would be put in a condition for profitable agriculture. The draining of the poorly drained areas constitutes an important problem. Some of these may be drained easily, but others will require considerable expense. While there are plenty of such soils in the area, they lie so low that they are covered by water much of the time. Their drainage would be a formidable undertaking and would necessitate cooperative rather than individual effort. The upland soil areas need much improvement. Their management includes their enrichment, and this by growing those crops that will improve the soil and furnish organic matter, in which they are all mostly deficient. The poorer grades of the rolling sandy soils can be most advantageously utilized by reforesting them or by using them for stock ranges. More forage crops should be grown, the number of stock reduced, and the breeds improved. While progress is being made in most agricultural lines, there is still room for improvement.

SOILS.

The soils of Florida are designated broadly by their characteristic forest growths. Certain conditions of surface in reference to character of soil material and depth and the surface configuration and position with reference to drainage give marked differences in vegetative growths. Thus a popular classification of the soils has for a long time existed, based upon the growths found upon the land. "Pine land" and "hammock land" are terms in general use. Pine land, as the term implies, comprises land on which the tree growth consists of pine. This is mainly longleaf, there being only a scattering growth of shortleaf pine. The pine lands are recognized in several grades, according to the size and stand of trees. The longleaf pine is the main growth on the sandy types of soils although there are some exceptions. The pine lands in the Ocala area consist of the "rolling pine lands," including "third-rate land," "open pine woods," and "flatwoods." The first mentioned is characterized also by a scrubby growth of blackjack oak and a sod of wire-grass, as in all pine lands. The rolling pine lands with blackjack are of deep sand and excessively drained. They are held in low estimation. The "open pine woods" refer to those forested areas in which there is no undergrowth. They occur on a better grade or phase of the deep sandy soils, having usually a smoother, flat, or undulating surface, not many feet above the water table or not far to clay. This condition is not favorable to the growth of blackjack oak, but water oak and turkey oak will come in when the pine is removed. This class of sandy land is considered of fair quality. In this division there also occurs high, open pine woods land, with heavy clay subsoil, which is almost as valuable as land that is considered "first-rate pine land," the stand being close and the trees large.

The "flatwoods" are the flat, low-lying areas in which the trees are usually slender and do not reach the usual height. There are some differences in this land. What are known as the "palmetto flatwoods" are most common. In this there is a more or less thick growth of scrub saw palmetto, with occasionally some gallberry and in open spots wire-grass. The soil is a white sand, underlain at about 2 feet by a brown substratum known as "hardpan." This hardpan is said to prevent the rise of capillary water. During rainy spells the soil above becomes very wet or covered with water, but it soon becomes dry and is very droughty. This class of land is considered almost worthless, but in other sections of the State where subirrigation systems have been put in and organic matter incorporated with the soil it has been successfully used for trucking. A type of open flatwoods occurs in association with the foregoing. It lies a little lower, is more or less wet, and instead of scrub saw palmetto the gallberry is found. The term "gallberry flat" is sometimes applied. This soil is dark colored, owing to the humus present, and in places is somewhat mucky. When drained it is considered excellent for trucking, such crops as celery, cucumbers, and lettuce doing especially well.

The term "hammock" has a rather broad meaning, but as generally used refers to the growth of hardwood. However, it often goes further, in that there must be leaf mold, and the soil darkened by the content of humus. The tree growth consists mostly of live oak, water oak, white oak, hickory, magnolia, and in the more moist places bay, gum, black ash, and cabbage palmetto, and there is a rather thick undergrowth of other vegetation.* "Light" and "heavy hammock" are terms that refer to the stand of vegetation present and to the texture of the soil. The "heavy hammock" is either almost impenetrable jungle, or heavy clay land. The term "light hammock" indicates sandy hammock land, or hammock land with a light growth. The predominance of any particular tree suggests such terms as "hickory and oak" hammock, "cedar hammock," etc. There are a number of terms used in connection with hammock land which refer to some characteristic feature. With reference to position, hammock land is either "low" or "high hammock." The "low hammock" is found in low positions in this area in association with swamps, being slightly above the latter, and quite often of a semiswampy character. The "high hammock" is rolling land, in which clay is found near the surface. Portions of this variety of hammock are now covered with pine, although it is said the original growth consisted of hardwood.

A geological or mineralogical designation is also applied to certain varieties of hammock. The terms "calcareous" or "noncalcareous" are also used, according to the origin of its material. In this area hammock underlain by marl is called "marl hammock."

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*It may be said that fires have played an important part in determining the tree growth. Young hardwood growth will not stand being burned over very well, while pine is ordinarily injured but little. In the early days the Indians fired the woods, in order to hunt game more easily.

If this is a shell marl, or shells are found in the soil mass, the term "shell hammock" is used.*

In the classification and separation of the soils found in this survey a number of factors were considered, such as the physical properties, the source of material and its mode of origin, the topographic features and position as to drainage, the characteristic vegetation, and the agricultural value. For convenience in classification and correlation soils of like properties, derivation, and position as to drainage are grouped in soil series. The series are divided into types, which differ in the texture of the component particles. Exclusive of Swamp, 17 types of soil were mapped in the Ocala area. These fall into six series.

The surface soils of the area are, with two exceptions, sandy. The members of three series consist of sand throughout the soil profile to a depth of 36 inches or more. The other three series include types having clay at or near the surface. The textural range of the sandy material is from medium to fine. Such textural variations are localized. In the western half of the area the texture of all the soils is fine, while to the east they are of coarser or medium grades.

The Ocala area, as previously mentioned in this report, is included in the limestone region of the State, limestone underlying the entire area at varying depths. The limestone is of varying composition, and consists of consolidated marine sediments belonging to the Oligocene of the Tertiary period.

There are two divisions of the Oligocene—the Vicksburg limestone and on top of this the Apalachicola group of formations, which include impure limestones, clays, and sands or sandstones. In this area the Apalachicola rocks have practically all been weathered to the soil. The Vicksburg is a white, soft, porous limestone, with included beds of marl and chert. The soil of the "high hammock" land has been affected more or less by material derived from cherty beds of limestone. In the low-lying areas flinty outcrops occur. Evidently the limestone has had no effect on the deep superficial beds of sand. In the western part of the area phosphatic rocks have been formed, and these underlie the sand at depths so great that they too do not have influence on the overlying surface soils.

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*For more complete details of the classification of soils as given in the above paragraphs see the Florida State Geological Report, particularly the 3d and 4th annual reports.

There is a deep mantle of superficial sands overlying most of the area, except the high hammocks, from which it may have been eroded, if, indeed, it ever covered them.* The superficial sands fall into three series—Portsmouth, Leon, and Norfolk. These occupy low-lying flatwoods to undulating and rolling higher lands. The Portsmouth and Leon soils occupy low-lying to depressed, poorly drained areas, mostly bordering bodies of Swamp. The Portsmouth soils are situated slightly above the Swamp. Existing under poorly drained conditions, organic matter has accumulated in the soil. They are black in the surface portion and rich in organic matter, in part rather mucky. The subsoils are light-colored gray to mottled gray and yellow. These soils are in an acid condition and need liming before being suitable for most cultivated crops. They make excellent trucking soils when drained. Two types of the Portsmouth series were mapped, the sand and fine sand.

The Leon soils comprise the "palmetto flatwoods." They are only slightly elevated above the Portsmouth, but while wet a part of the year they are very dry at other times. These are gray to nearly white soils of low organic matter in the surface portion except occasionally in the upper inch or two. Usually within about 2 feet of the surface a brown or dark-brown layer of sand, locally known as hardpan, is encountered. The brownish color and compact nature of this layer seem to be due to the presence of both organic matter and iron compounds. When wet this substratum is easily penetrated, but when it dries out it becomes compact and resists penetration by plant roots and moisture. It is believed to prevent the rise of capillary water, hence the droughty nature of the surface soil. This hardpan occurs near the top layer of the water table. The Leon sand and fine sand were mapped. Each of these includes a hammock phase supporting a hardwood growth. The soil of the hammock areas, however, does not differ from the average, except that the hardpan substratum is deeper or entirely absent. There is also a "pond" phase representing what is known as sand ponds. Water does not remain long in these. Dog fennel is the characteristic growth of such shallow ponds.

The Norfolk soils, including the sand and fine sand, lie high and are well drained. These are grayish soils with yellowish or yellowish-gray subsoils. The types mapped constitute the main areas of deep sandy land.

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*These sands are now referred to the Pleistocene period. Heretofore they have been regarded entirely as marine sedimentary deposits of the Pleistocene, reworked by water or by the wind. There is said to be evidence that the material is residual. See State Geological Survey reports of Florida.

The hammock soils are comprised in three series—the Parkwood, Fellowship, and Gainesville. The heavy, clayey material of these is residual from the underlying rocks. In places the sandy surface portion evidently consists of unconsolidated sedimentary material. The Parkwood soils, comprising a clay loam and fine sandy loam, are characterized by the dark-brown or brown color of the surface soils and by a marly subsoil of yellowish to nearly white color. These are strong, productive soils, but low-lying and in part poorly drained.

The Fellowship series includes five types—the sand, sandy loam, fine sandy loam, clay, and clay loam. These have grayish to black and almost mucky surface soils, underlain by plastic clay, of a mottled drab, yellow, and brown color, including frequently some red. The subsoil material is dense and impervious. The low hammock areas are poorly drained, of semiswampy character, and support a hardwood growth. The high hammocks are not so well drained as might be expected in soils occurring in such sections.

The Gainesville series comprises four types in this area. These are the calcareous high hammock soils of the area. The clayey and probably some of the sandy material is derived from limestone and associated sandy rock formation. These soils are characterized by brownish-colored or slightly reddish-brown sandy surface soils, frequently with some limestone fragments on the surface and in the soil mass. These are well-drained and productive soils, having a wide range of crop adaptability. The heavy subsoil and substratum material consists of plastic clay of a yellowish-brown to mottled yellowish and drab color.

Considerable areas have been mapped as Swamp. These are low lying and more or less covered with water throughout the year. Cypress is the characteristic growth. Flood waters spread over the areas, depositing rich sediments, and much organic matter is added by the decay of the existing vegetation. The soil material of the Swamp varies greatly and no attempt was made at type separation, as much of the Swamp was covered with water at the time of the survey. A great deal of the land consists of muck or peat overlying marl, the largest areas being indicated around Lake Panasoffkee, including the areas covered with cypress and saw grass.

The muck and peat are of little value at present, owing to the fact that they are covered with water. These lie so low that drainage would be quite expensive.

The names of the different soil types and their actual and relative extents are given in the accompanying table:

Areas of different soils.

Soil	Acres	Per ct.
Norfolk fine sand	217,152	35.2
Loamy phase	8,640	
Norfolk sand	198,528	31.3
Loamy phase	2,240	
Leon fine sand	53,120	8.3
Swamp	32,640	6.1
Marl subsoil phase	6,400	
Gainesville loamy sand	24,320	3.8
Leon sand	23,040	3.6
Gainesville fine sand	17,280	2.7
Fellowship sandy loam	14,720	2.3
Gainesville sandy loam	11,200	2.1
Pinewoods phase	2,560	
Gainesville fine sandy loam	8,640	1.3
Portsmouth sand	5,440	.9
Portsmouth fine sand	5,440	.9
Fellowship fine sandy loam	4,480	.7
Parkwood fine sandy loam	1,920	.3
Parkwood clay loam	1,280	.2
Fellowship clay	960	.1
Fellowship sand	640	.1
Fellowship clay loam	640	.1
Total	641,280	

NORFOLK SAND.

The Norfolk sand consists of medium-textured loose sand that extends to a depth of 3 feet or more. This constitutes one of the extensive deep sandy types of the area. Locally the greater part of the type comes under the popular classification of "rolling pine with blackjack" land. but this vegetative classification is not applicable to the whole of the type as mapped, as will be noted later.

The Norfolk sand to an average depth of about 6 inches varies from a gray to light-gray loose sand, underlain by light yellowish gray or pale-yellow medium sand, which continues to a depth of 3 or more feet. In some places the soil continues to a depth of several feet as slightly yellowish gray sand overlying more decidedly yellow sand. In other places the color is a decided yellow to orange yellow, with sometimes a quite noticeable reddish tinge. The surface is usually loose and only slightly coherent, the coherency being due to the small organic-matter content, which also imparts the darker color. The subsoil is generally even more loose and incoherent than the soil, as it lacks the organic matter. While the texture in any one place is uniform throughout the soil profile, there are variations throughout the type as a whole. In the southeastern part of the area the type averages a little coarser, approaching at times a coarse sand. and where it merges into the Norfolk fine sand there is a long gradation between them in which the texture approaches that of a fine sand. There are also variations in different places in the relative proportions in size of the soil particles, particularly as to the finer grades, but there are always enough of the coarser particles to impart the coarser feel.

Norfolk sand, loamy phase.—A variation in the type is shown in the eastern part of the area by means of rulings, particularly to the south and southwest of Belleview along the Seaboard Air Line Railroad. In these areas the soil is somewhat darker and the subsoil a deeper yellow and both are slightly loamy, although the lower subsoil becomes loose and incoherent. The areas appear to be of higher agricultural value than the average.

There are some low-lying areas in depressions associated with the high hammock soils near Ocala that support a hammock growth. These areas have considerable leaf mold in the surface soil, rendering it darker than the typical hammock phase, although otherwise identical with it. Another vegetative growth is also indicated. This is in areas of scrub outlined from the remainder of the type, which are in marked contrast with the surrounding areas of the type, owing to the different vegetation, being covered by stunted evergreen oaks and a shortleaf locally called "spruce pine." In these areas a marked contrast to the average of the type is the dazzling white appearance of the surface, which upon examination is found to be a mere veneer not over 2 inches deep, under which is encountered bright or ocherous-yellow colored sand. In texture and structure it does not vary from the average of the type. The largest area is known as the Big Scrub. This lies southward from Ocala.

While the greater part of the Norfolk sand has a substratum of sand reaching to a depth of many feet, there are some areas in which the sand is not over 4 to 6 feet in depth. A typical section of this kind is that northwest of Ocala, having a flat or slightly undulating surface, in which are found frequent outcrops of flinty limestone and around these some loose stone. In this section either the sand directly overlies the rocks or there is an intervening clay stratum. Rock outcrops occur occasionally in the lower and flat areas of the type and around the rims of some sinks. They are very rarely encountered in the rolling areas.

The Norfolk sand is, next to the Norfolk fine sand, the most extensively developed soil type in the area surveyed. It occurs in the eastern half of the area and in Marion and Sumter Counties. It is practically in one large, connected but irregular body, being limited by areas of flatwoods and swamps on its borders and interiorly broken by the projection of the high hammock lands as islands, as it were, and by the soils occurring in the depressed areas of sinks and basins.

The topography of the Norfolk sand varies from nearly flat or gently undulating to rolling or low hilly, rolling being the most common surface configuration. In looking over the areas of this soil it has a billowy appearance to some extent, but the ridges are not continuous, being rather a heterogeneous collection of low sandy knobs, conspicuous because of the depressions between, which are the result of the dissolution of the underlying limestones forming sinks or basins. The elevation ranges from 50 to 100 feet above sea level, the undulating areas averaging a little more than 10 feet or so while in the more rolling areas the change in elevation reaches 20 to 40 or 50 feet.

The Norfolk sand consists of a superficial mantle of sand of sedimentary origin laid down as a marine deposit during the Pleistocene period, when this part of Florida was submerged.*

The drainage of the Norfolk sand is excessive in that, because of its open, sandy character, the rains falling upon it pass quickly downward, seeking the permanent water-table levels or seeping into the sinks or to the swamps. The type maintains a small moisture supply at all times, but during hot, dry spells the crops suffer. Its moisture-holding capacity is greatly increased by the incorporation of organic matter. So readily does water pass into this soil that its cultivation is not interfered with by rains.

The Norfolk sand in the main constitutes one of the "pine lands" types of soil. Because of its generally rolling surface, it is known locally as "rolling pine lands." In addition to the pines some blackjack oaks are found over much of the land, the latter taking hold when the longleaf pine is removed. The pines attain a fair size, but the stand is rather thin. The pine lands are rated in classes according to the relative rate of growth of the trees, and this class of land comes in as third rate, although some of the better parts will grade as second rate. The more loamy areas support the growth spoken of as open pine woods, in which there is no undergrowth and blackjack does not come in to any important extent. The flatter or low-lying undulating areas, because of nearness to the water table, also support some post oak, water oak, and turkey oak. Where the turkey oak grows the land is considered of better quality. Such areas are found from Santos south along the Seaboard Air Line Railway.

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*The origin of these superficial sands is questioned. While their sedimentary origin is accepted by most geologists, there are some who consider them of residual origin or formed in situ from sedimentary rocks, the age being unknown because of lack of fossil remains. See Florida Geological Survey reports.

As previously mentioned, there are two other phases of this type, the hammock and the scrub areas. The former supports large trees of water oak and live oak, magnolia, hickory, cabbage palmetto, and some others. This growth is influenced by the better moisture conditions, the roots being able to reach the permanent water table. The scrub areas are characterized by a stunted growth of evergreen oaks and spruce pine. These areas are sharply separated from those of the rolling lands with pine and blackjack growth. There is apparently no difference in the soil to the depths examined, and no conclusive explanation for one growth taking hold to the exclusion of another can be given here. It was noticed, however, that the subsoil in the scrub areas was generally more moist, and this may account for the difference in the vegetation. There was no topographic change, the growth covering the higher as well as the lower situations. These areas of scrub are regarded as very poor and no attempt is made to cultivate them. There is no wire-grass growth in the scrub areas, but on the rest of the type there is a good wire-grass sod that early in the season affords fair pasturage for cattle, contributing somewhat to the value of the land.

The main value of the type has been its growth of longleaf pine, which usually is first worked for turpentine during a period of years and then cut and sawed into lumber. With the trees removed the greater part of this type has little value and is not usually desired for farming. The population over this type is sparse and many sections are occupied solely by negroes.

Some development is taking place on the better areas of the Norfolk sand near railroads, but there is not a wide range of crops produced. Naturally the type is one of low productive value. Fertilization is necessary to produce anything approaching good yields. The soil will make a small yield of corn—about 10 bushels to the acre.

Velvet beans grow well upon it and are an important crop. Cowpeas are also grown, being cut for hay. Crabgrass coming into the corn late in the season is usually cut for hay. Sweet potatoes are grown in small patches to supply the family needs. Watermelons constitute the money crop on this soil and large acreages are being devoted to it, from which considerable revenue is derived. Because of the wilt disease, however, the land can not be replanted to watermelons for a number of years. Cantaloupes are grown on some of the better areas, and with the advent of new settlers the production of other truck crops, particularly tomatoes, is being attempted. The better parts of the type, when the depth to the clay or water is not too great, are well suited to vegetable growing; but the application of organic manures in liberal quantity, as well as complete commercial fertilizer mixtures, are necessary on the best of this land. By plowing under green manuring crops, especially the legumes, this soil can be greatly improved. Cowpeas are useful for this purpose. The velvet bean makes a heavy growth, shades the ground, and is an excellent soil improver, especially when plowed in. A source of income is the growing of velvet beans for seed. The growing of this crop is general on the type.

Areas of the Norfolk sand in small tracts are sold for $10 to $25 an acre, but the greater part of the type is held at much lower prices.

NORFOLK FINE SAND.

The Norfolk fine sand is the most extensive soil in the area. It consists of a mantle of fine sand more than 3 feet deep. Slight variations occur in the type, but the surface 6 inches usually consists of a gray to yellowish-gray, loose fine sand. The grayish color is caused by the small organic-matter content, which in places is sufficient to make it quite dark, especially in the lower situations. Besides affecting the color above, this organic matter has a binding effect, making the soil, though loose, somewhat coherent. The soil below the surface 6 inches is of similar texture, but, lacking organic matter, it is usually a little more loose and incoherent, especially in the lower depths. The prevailing color of the soil is gray, yellowish gray, or pale yellow, but there are variations, in some places to a decided yellow or ocherous yellow, in others to a brownish or orange-yellow color, and occasionally even to a reddish color.

The type is free of stone as a rule, but occasionally around sinks there may be found outcrops of flinty ledges of the limestone formation. There is also a belt of flat to undulating country extending southeast from Standard and Earlybird in which there are frequent outcrops of the flinty rocks and some loose stone on the surface. Clay is found at 4 to 6 feet in places, but the soil is of the same texture and character as the general average of the type, though a little lighter in color, being light yellowish or grayish yellow, approaching the color of the Leon fine sand. In addition, it is characterized by a scattering growth of saw palmetto, which is rarely seen on most of the Norfolk fine sand.

Slight variations in texture are found in different parts of the type. While it all averages a fine sand, it tends in places toward a coarser texture, and in the southwestern part of the area approaches that of a very fine sand.

The Norfolk fine sand is confined to the western half of the area, in Levy, Marion, and Citrus Counties. It is found in practically one large, connected body, broken to some extent by areas of other soil types.

The topography of the type is mostly rolling, a large part of it constituting the highest rolling lands in the area. The surface is for the most part irregular and choppy, owing to the presence of depressed basins caused by the solution of limestone beds and the falling in of caverns. The change in elevation from the sunken areas to the higher lands surrounding ranges from 20 to more than 100 feet. Most of the basins occur at an elevation of 40 to 60 feet above sea level, but there are some that are as low as 10 to 20 feet above. The average elevation of the tops of the knolls is 100 feet or more above sea level and the highest elevation of the area occurs in this type, being 220 feet above sea level. This point is west of Hernando. In some parts, especially east of Dunnellon and in the vicinity of Earlybird, the surface smooths out to gently undulating.

There are no surface streams found within this type, with the exception of Wekiwa Creek, or Blue Spring Run, which is really a subterranean stream coming to the surface. The sand is porous and all the water falling upon it passes readily downward to the permanent water table or seeps into the sinks and subterranean channels in the porous limestones beneath.

This soil holds only a small amount of moisture, and in its present condition will not support crops during dry, hot weather, but by increasing the organic-matter content it can be made to maintain a more adequate supply of moisture.

The Norfolk fine sand, like the Norfolk sand, is a superficial mantle of sand, most probably of Pleistocene age. This soil overlies the extensive hard-rock phosphate beds of this section of the State.

There is very little agricultural development on this soil, partly because it is naturally a thin soil of low productivity. For good yields all crops have to be heavily fertilized with complete mixtures or barnyard manure. It is held in large tracts by the phosphate mining companies and as interest centers in the mining operations no effort is put forth on the soil. Large tracts of this land have been completely deforested, the wood being used for the drying of the phosphate rock. Around mines the country presents a desolate appearance.

On the flatter areas of the type east of Dunnellon and along the Ocala & Southwestern Railroad there are some lands in cultivation. Large acreages are being put in watermelons, for which this soil is well adapted. Velvet beans and cowpeas are also grown, and a small yield of corn is obtained. Sweet potatoes do fairly well. Vegetables do well on some of the better spots, but no market gardening is done on this soil. With an overhead system of irrigation the better areas would be well suited for gardening. Its greatest need is the incorporation of organic matter. Velvet beans and cowpeas are the best crops to produce. Corn and melons have to be fertilized, the latter requiring heavy applications.

The principal tree growth on this land is longleaf pine, which attains a fair size and a moderate stand. The blackjack oak occurs with the pine, and when the latter is cut the former occupies the land. There are some areas of open pine woods, especially on the better parts of this type, that support a sod of wire grass, which affords good grazing early in the season. The value of the land is low—only a few dollars an acre.

Norfolk fine sand, loamy phase.—While the type as a whole is a loose, incoherent sand, there are areas occurring in the depressions, especially in Citrus County, in which the soil is affected by wash and is a little more loamy than the average. There are also indicated some areas near Dunnellon which, while not in depressions, are a little more loamy, and in the vicinity of Heidtville there is a large area having a generally flat surface that is also somewhat loamy, the clay not being very far beneath the surface. Two large areas of this phase, lying near Elecia and Inverness, in Citrus County, were also mapped.

GAINESVILLE LOAMY SAND.

The surface soil of the Gainesville loamy sand consists of about 10 inches of a grayish-brown to brown, medium-textured loamy sand, ranging to reddish brown in places. The subsoil is a yellowish-brown or brown to reddish-brown loamy sand, which becomes a little more loamy with depth, usually changing within 36 inches to a sticky sand or sandy loam, which in turn grades below into a substratum of friable sandy clay. In some places, however, the sandy clay is encountered within 24 inches of the surface. It is of a brownish-yellow color and quite frequently has a reddish tinge. In many places there is 3 or 4 inches beneath the surface a dark-brown to brownish-black, compact layer having something the nature of hardpan, although not cemented, the color being caused by the staining of the soil grains by organic or ferruginous matter.

As mapped the type includes some areas of a loose sand, representing the Gainesville sand, which were not separated, owing to their small extent. Some included patches closely resemble the Norfolk soils in having a somewhat grayish color in the surface portion and yellowish color beneath, and in being rather loose and incoherent in structure from the surface downward. Areas are encountered in which the surface is loamy and close structured, while the subsoil is not especially loamy and is loose and incoherent in the lower part. Limestone fragments are quite commonly found in the subsoil and the bedrock itself may occasionally be reached within the 3-foot section. Small areas occur where limestone fragments are scattered upon the surface, as well as throughout the soil and subsoil.

There is some variation in texture in the Gainesville loamy sand from place to place. The sand particles of the soil are irregular shaped and rather sharp, and generally enough of these are of sufficient size to give a rather coarse feel, making the texture coarse medium, but it varies, on the other hand, to a fine medium texture, with a small range in the size of soil grains.

The loamy sand is the most extensive of the Gainesville soils. Comparatively large areas occur in the eastern part of the survey in Marion and Sumter Counties. The greatest development is around Ocala, and there are large areas around Belleview, Summerfield, and Oxford. It forms high hammock land, occupying the broad, gently sloping, arched areas of hammock, mostly between elevations of 90 and 100 feet above sea level. Some of the areas are quite broad and flat, but usually there is some slope. This surface is further modified by the presence of depressions or large basins and by sink holes. There is an entire lack of surface streams, the drainage being accomplished by the water percolating downward and finding outlets into the sink holes or subterranean channels. The soil texture and the underlying rocks are porous, so that percolation is accomplished readily. All of this land is thoroughly—some of it excessively—drained, although most of the type, owing to its loamy character and heavy clay subsoil, holds moderate supplies of moisture. None of it is found wet.

This soil material is entirely or mainly of residual origin, having been derived from the weathering of limestones of the Vicksburg group and the sandstone formations above it. Some of the sand in the surface portion may represent original unconsolidated sedimentary material, but the brownish-colored and clayey material undoubtedly is a residual product from the underlying rock.

The Gainesville loamy sand is known locally as "hammock land," and when the soil mass is dark brown or has a reddish cast, as it is in spots, it is spoken of as "chocolate hammock." It also, in part, at least, with the other Gainesville soils, comes under the term "calcareous hammock" because of the calcareous origin of its materials. It is also known as "mixed hammock," because its growth consists of mixed hardwood and pine, though hardwood predominates.

A large part of this soil is cleared and under cultivation. It is easy to cultivate, productive, and adapted to a wide range of crops. All the general farm crops are grown upon it. Corn gives 25 or more bushels to the acre on the average, but when it follows a highly fertilized trucking crop the yields run much higher. Either peanuts or velvet beans are grown with the corn. The velvet beans are generally put in as a separate crop, and a yield of 15 to 20 bushels of beans to the acre is considered good. Sugar cane grown on this soil makes, as a rule, a dark-colored and rather strong sirup. The yield, however, is high.

Winter oats are grown and are cut and cured for hay. They make only an ordinary growth, not doing so well as on the heavy clay hammock soils. The beggarweed thrives on this soil, making a heavy growth. Cowpeas also do well upon it, being grown for hay and to some extent as a soil improver. Irish potatoes, especially on the deeper sandy areas of the type, have not paid as a commercial crop, but sweet potatoes do well.

Trucking is done more largely on this soil than on any other, It has a wide range of adaptability and is a warm, early soil. Cantaloupes have been and are still an important crop. Yields of 100 crates to the acre are obtained with the use of 600 to 700 pounds of commercial fertilizer. The Rocky Ford variety is grown exclusively and is of excellent quality. Cucumbers, snap beans, and eggplants are other truck crops that succeed. Watermelons yield as high as a carload to the acre, while one-half carload is considered a fair yield on most soils. At least two crops are taken every year from this soil. Where truck crops are grown the common practice is to follow with corn and peanuts. Cowpeas sometimes succeed cantaloupes or watermelons, and after these later planted crops mature a cutting of crab grass can be obtained for hay. Where general farming is practiced corn and peanuts are grown, and then the crab grass is cut, or beggarweed, if it happens to come in. The peanut crop is either harvested or left on the ground as feed for hogs.

This land is held in good-sized farms, and the owners generally are prosperous. It lies close to the towns and railroads and is held at prices ranging ordinarily from $20 to $75 an acre, and much of it cannot be purchased even at the higher figure.

Mechanical analyses of typical samples of the soil and subsoil of the Gainesville loamy sand gave the following results:

Mechanical analyses of Gainesville loamy sand from 2 *mi. southeast of Ocala* (*soil* 0-10, *subsoil* 10-36 *in*).

Number	Description	Fine gravel	Coarse sand	Medium sand	Fine sand	Very fine sand	Silt	Clay
		Per ct.	Per ct.	Per ct.	Per ct.	Per ct.	Per ct.	Per ct
260811	Soil	0.6	12.9	26.5	40.1	10.4	4.3	5.2
260812	Subsoil	.2	12.8	25.6	39.4	10.7	3.8	7.5

GAINESVILLE FINE SAND.

The surface soil of the Gainesville fine sand consists of 5 to 8 inches of a brown or brownish-yellow fine sand to loamy fine sand, underlain by brownish-yellow loamy fine sand that becomes lighter colored with depth. Like the Norfolk fine sand, it is often loose and incoherent in the lower depths. Just below the surface of a great deal of the type there is a compact dark layer, resembling a hardpan, which contains considerable organic matter. When dry this compact layer breaks up into slabby pieces which soon crumble. The type also includes some areas of gray-colored surface material and light-colored subsoil which is only slightly loamy, representing rather a gradational phase between this type and the Norfolk fine sand.

The Gainesville fine sand occurs in the western part of the area, associated with the Norfolk fine sand. It is found in a belt entering at the northwest corner of the area from Levy County and extending southeast to Juliette. Around Dunnellon there is another area, the two areas being separated by a body of Norfolk fine sand. There are also some small areas in Citrus County, two of which occupy islands in Lake Tsala Apopka and others the domelike tops of knolls. The topography of the larger areas is that of the Norfolk fine sand, the surface being rolling and somewhat ridgy or hilly and marked by sunken areas, in some of which are ponds. This land is well drained and lies well for cultivation. There is no surface run-off, the waters readily passing through to lower levels. It is, however, more retentive of moisture than the Norfolk fine sand, though regarded as a droughty soil.

The origin of this type is not clear. It is probably residual, at least in part from the Vicksburg limestone or an associated arenaceous rock. In some places small fragments of a ferruginous sandy rock occur on the surface. These show a rather weak cementation or a state of partial decomposition, being readily broken down to sand. In the lower depths the formation becomes somewhat sticky and clay is sometimes found, indicating residual origin, for it is believed that most of the clay material of the area is residual from the underlying rocks.

There has been a little development of agriculture on this type of soil, some of the land having been cleared and occupied early in the settlement of this region. Fair yields are obtained. Corn gives 10 to 15 bushels per acre without fertilization. Oats, cowpeas, and velvet beans are grown and cut for hay. Crab grass, crowfoot, and sandspur come in after the corn, and a fair crop of hay is cut in the fall. Sea-island cotton has been grown on this land, giving yields as high as 500 pounds of seed cotton per acre. Before the freeze of 1894-95 there were orange groves on most of the farms, from which some profit was derived. No groves remain now. While the soil does fairly well, farmers say it will not stand continuous cropping and that it is a good practice, and one followed generally, to let the land lie idle every other year and turn under the growth of weeds and grasses. The same object could be attained by growing cover crops and plowing them under while cultivating the land every year. Rather liberal fertilizer applications are necessary for best results with all crops.

The areas in Tsala Apopka Lake are devoted to citrus fruits, which do well. Here the surface is not far above the water table. These areas as mapped are rather variable, including areas of Norfolk fine sand, Gainesville fine sandy loam, and Gainesville fine sand so intricately associated as to preclude satisfactory separation on the scale used. The dominant soil, however, is the Gainesville fine sand. In these areas some limestone fragments are present.

The Gainesville fine sand supports the type of vegetation known as "open pine woods," the growth being longleaf pine, which attains a good size and is fairly close. There is no undergrowth except a strong sod of wire grass.

Mechanical analyses of typical samples of the soil and subsoil gave the following results:

Mechanical analyses of Gainesville fine sand from 6½ mi. north of Dunnellon (soil 0-6, subsoil 6-36 in.).

Number	Description	Fine gravel	Coarse sand	Medium sand	Fine sand	Very fine sand	Silt	Clay
		Per ct.	Per ct.	Per ct	Per ct.	Per ct.	Per ct.	Per ct.
260817	Soil	0.2	1.4	8.4	71.1	10.6	2.5	5.7
260818	Subsoil	.0	1 7	9.7	73.5	8.1	2.3	5.0

GAINESVILLE SANDY LOAM.

The Gainesville sandy loam is a rather variable type in color, depth of soil, and vegetative growth. There are two kinds of vegetation on this land—hardwood and pine. The hardwood hammock land averages a darker-colored soil with less depth to the clay subsoil than the pine-woods phase, but there are many places in which there is very little difference, as far as the appearance of the soil is concerned, between the material of the typical soil and the pine phase, each grading into the other. The hammock land varies from brown to yellowish-brown medium sand to loamy sand or light sandy loam. Included in these areas are spots of gray sand, so that the surface is quite variable in color and texture. The depth of the soil ranges from 8 to 24 inches. Beneath this there is encountered a brownish-yellow clay, varying from sandy to stiff and plastic, which generally becomes heavier with depth. In places the underlying rock is found at the surface or above a depth of 4 or 5 feet. In the subsoil, especially in the lower part, occur limestone fragments some of which have weathered to an advanced stage. Fragments of the same kind are also found scattered over the surface in spots. In places the subsoil has a decidedly brownish color. There is also a variation showing mottled brown and yellow and some bluish drab, the latter approaching that of the closely related Fellowship type, into which it grades. A characteristic of this type is the irregularity in shape and size of the soil grains. While it is composed largely of sand particles of medium grade, there are enough of the larger grades, with irregular or angular shape, to give a coarse feel to the soil as a whole.

The Gainesville sandy loam is of comparatively small extent. Its largest development is on the high hammock lands immediately south of Ocala. Except in the case of the area at Coleman and a few others, it occupies the "high hammock lands." These are irregular-shaped ridges or elevated sections marked by large depressions and sink holes, which have no surface outlets. In part they are distinct ridges. The highest elevations range from 100 to 150 feet above sea level. The slopes are smooth and comparatively gentle. They erode badly, however, if care is not taken in their cultivation.

The Gainesville sandy loam has good surface drainage, which is effected through the numerous sink holes and larger depressions, so that there is no need for artificial drainage. It is fairly retentive of moisture, as with its clay subsoil it maintains generally a sufficient supply of moisture to grow and mature all the general farm crops.

The Gainesville sandy loam is, on the high hammocks, largely, if not entirely, of residual origin, having been derived from limestone of the Vicksburg group and the associated sandy formations. The lower areas of the pine-woods phase have a subsoil largely residual from limestone, but the soil portion may be to some extent of sedimentary origin.

The Gainesville sandy loam is one of the better soil types of the area and much of it is cleared and under cultivation. It produces good yields of all the general farm crops and is devoted to trucking as well. It is a warm soil as a rule and crops develop rapidly on it. Sea-island cotton used to be grown on this soil type and gave fair yields. The shallower and heavier phases are especially well adapted to cabbage. Tomatoes and snap beans also yield profitably. Cucumbers and cantaloupes, particularly the latter, do well on this soil, and watermelons are grown to some extent on the deeper and more sandy areas. Fertilizers in large quantities are required for all these crops, but their application is repaid in the size and quality of the yields. All of the type should be cleared and cultivated, and with a system including general farming and truck growing, thus affording a broad crop rotation, the farmers should be successful. This soil, for the most part, at least, would be greatly benefited by the use of organic manures. All the barnyard manure possible should be applied and this should be supplemented by plowing under green crops. Beggarweed, which grows well upon this soil, is especially desirable for this purpose.

The vegetative growth on the Gainesville sandy loam varies. The hammock growth is of mixed character, including both hardwood and pine, the former consisting of live oak, red oak, hickory, magnolia, sweet gum, cabbage palmetto, and other species. The pine growth is scattering, the longleaf pine growing large. There is also shortleaf pine in some areas.

The value of this land ranges from $25 to $75 an acre, depending upon location. The greater part is located well in reference to railroad facilities.

Gainesville sandy loam, pine-woods phase.—The pine-woods phase of the Gainesville sandy loam resembles that of the Gainesville fine sandy loam, except in texture. It consists of a gray or yellowish-gray sand, changing in places to yellowish or snuff-colored to brownish-yellow medium sand, averaging between 15 and 24 inches in depth, and resting upon a brownish-yellow clay, varying from sandy to stiff and plastic. There also occur in this clay soil, especially where near the rock, some rotten limestone fragments of gray to yellowish-gray color, giving the clay a speckled or mottled appearance. Flinty outcrops of the limestone formation are also to be seen, and occasionally some loose, irregular blocks of limestone. This phase has a more nearly level topography than the typical soil and supports a rather close growth of longleaf pine, which reaches a good size. Areas of the pine-woods phase occur near Coleman, in Sumter County.

Results of mechanical analyses of samples of the typical soil and subsoil of this type are given below:

Mechanical analyses of Gainesville sandy loam from 5 *miles south of Ocala* (*soil*, 0-12, *subsoil* 12-36 *in.*).

Number	Description	Fine gravel	Coarse sand	Medium sand	Fine sand	Very fine sand	Silt	Clay
		Per ct.	Per ct.	Per ct.	Per ct.	Per ct.	Per ct.	Per ct.
260823	Soil	0.8	14.0	23.5	41.4	11.8	5.5	3.1
260824	Subsoil	.6	9.3	14.8	29.7	8.3	4.9	32.4

GAINESVILLE FINE SANDY LOAM.

The surface soil of the Gainesville fine sandy loam consists of a few inches of gray to dark-gray fine sand varying in places to a light or grayish-brown fine sand and again to a yellowish-gray or yellow fine sand, usually slightly coherent. The depth of this soil mantle varies considerably, and within short distances ranging from 8 or 10 inches to 3 feet or more, but usually the clay subsoil is encountered at 15 to 24 inches below the surface. Areas where the soil exceeded 3 feet in depth are common, but are generally too small to show on the map, and for this reason were not separated. The subsoil consists of a yellow to brownish-yellow or light-buff clay, varying from a fine sandy clay to stiff plastic clay, the former being generally friable from the sand intermingled with it. Usually the clay content increases with depth and the structure becomes more plastic. Small fragments of rotten limestone are frequently found in the subsoil, especially in those places where limestone outcrops or lies near the surface. The quantity of this rotten rock material generally increases with depth. Around Lecanto the type has a darker-colored surface and is somewhat loamy in places, being a light sandy loam of dark-brown color, underlain by brownish-yellow or buff sandy to stiff plastic clay. Throughout the extent of the type are to be seen outcrops of flinty ledges of the Vicksburg formation and about these outcrops irregular fragments and blocks of the flinty rock over the surface. The rocky spots, while having in some instances enough rock to interfere with cultivation, were too small to indicate separately on the map.

The Gainesville fine sandy loam is of comparatively small extent. The areas are scattered over the western and central parts of the survey, where they are associated with other fine-textured soils, and they occur also with the high hammock lands in the northern part, from York to Earlybird. There is also an area on the extreme northern boundary west of Standard. In the southwestern part of the area, in the vicinity of Lecanto, in Citrus County, there is a considerable body broken by other soil types. There are also a few small areas associated with the soils along the Withlacoochee River. The greater part of the type is flat to gently undulating. With the hammock lands, it occupies the flat or undulating areas between the high hammocks as extensions from those slopes occurring between the 70-foot and 90-foot contours. The area around Lecanto has considerable relief, being conspicuously rolling, ranging from 20 feet elevation in sink holes to slightly over 100 feet above sea level on the hilltops. All the areas are marked by sink holes of varying sizes and depths, caused by the removal of limestone by solution, the type resting upon limestone formations at comparatively slight depths.

The Gainesville fine sandy loam has good drainage, the surface waters percolating either directly downward into the porous limestones or into the sink holes. The sandy soil mantle, because of its being underlain by clay, is fairly retentive of moisture.

The subsoil of the Gainesville fine sandy loam is probably for the most part, if not entirely, of residual origin, from the Vicksburg group of limestones. The rocks have weathered irregularly, and the more resistant parts protrude here and there above the surface. In some areas partially weathered limestone is occasionally found on the surface and in the soil mass. The surface sandy mantle is of doubtful origin. It is possible that much of it is water-transported material deposited over the residual clayey subsoil. In part it may also be residual, representing the siliceous parts of the parent limestone.

This type was one of the earliest soils in the area to be cleared and cultivated. It had good natural drainage and the light soil was easy to cultivate and fairly productive. It is now devoted entirely to general farm crops and makes fair yields. It is a soil that would be well suited to trucking, but its location, with the exception of a few areas, is at present too far from shipping points. Having a clay subsoil, it would be adapted to citrus-fruit growing, providing the situation were right. None of the areas, except those along the Withlacoochee, lie near bodies of water.

The type is partly forested, the growth being longleaf pine, fairly thick and of good size. The forested areas are characteristic of open pine woods, there being no shrubby undergrowth. It supports a good sod of wire grass.

As the lands are mostly remote from towns and railroads, their price is not high, probably ranging from $10 to $25 an acre, although most of the areas have been cleared and occupied as farms.

The average results of mechanical analyses of samples of the soil and subsoil of the Gainesville fine sandy loam are given in the subjoined table:

Mechanical analyses of Gainesville fine sandy loam. Nos. 260813-260814 *from* 8 *miles west of Wildwood (soil* 0-8, *subsoil* 8-36 *in.); Nos.* 260821-260822 *from* 1 *mile north of Lecanto (soil* 0-18, *subsoil* 18-36 *in.).*

Number	Description	Fine gravel	Coarse sand	Medium sand	Fine sand	Very fine sand	Silt	Clay
		Per ct.	Per ct.	Per ct.	Per ct.	Per ct.	Per ct.	Per ct
260813, 260821	Soil	0.4	3.1	9.7	54.1	22.5	4.5	5.7
260814, 260822	Subsoil	.2	1.8	6.1	36.3	13.0	8.7	33.9

The following sample contained more than one-half of 1 per cent calcium carbonate ($CaCO_3$): No. 260814, 3 per cent.

FELLOWSHIP CLAY LOAM.

The Fellowship clay loam is a variable type of soil. It ranges from a clay loam to clay, often having a surface covering 3 to 5 inches deep of sand, loamy sand, or even sandy loam. Over the greater part of the type it consists of 4 or 5 inches of a clay loam, with some sand, varying in color from black to brown or brownish gray. The subsoil is a stiff, plastic clay, somewhat sandy in places, becoming heavier and more plastic with increase in depth. The subsoil color ranges from black to bluish drab, becoming lighter drab with depth. In places it is almost a gray clay, very sticky and gumbo-like. The clay contains small particles of light-colored sandy rock and possibly some fragments of limestone. In places there are small spots where the subsoil is exceedingly stony. There usually occur scattered upon the surface in small quantities fragments of angular or subangular, spongy-looking sandstone, ranging in size from small chips to fragments several inches in diameter.

The Fellowship clay loam is of small extent, consisting of small areas on the high hammocks south and west of Ocala. It is typically developed on the slopes, and these are about the steepest in the area. While this land lies so that the surface run-off is good, yet because of its close, clayey character it holds a great deal of water, becoming puttylike, boggy, and difficult to handle when wet and hard to break up when dry. Gullies are easily eroded on the slopes if care is not taken to prevent their formation.

The Fellowship clay loam is of residual origin. A variety of rocks belonging to the Oligocene formations seem to have entered into its composition. Part of the material appears to be derived from limestone beds and part from sandstone, probably more or less calcareous, associated with the limestone.

The Fellowship clay loam, because of its generally moist condition and close character, is a cold and comparatively late soil, but it is nevertheless very strong and productive. It supports a strong grass sod, broom sedge particularly making a luxuriant growth. Besides the grasses, oats make a good growth and yield well. It is said to be excellent for cabbage. Snap beans do well upon it. With the exception of one area, this soil is found away from railroads and is mostly in grass for pasturage. It supports a mixed growth of hardwoods and longleaf and shortleaf pine.

In managing this type the aim should be to loosen it up and deepen the surface soil. This can be done by plowing in all the coarse litter possible and by the use of lime. A part of the soil would undoubtedly be benefited by subsoiling, which, on account of the intractability of the clay, would have to be done gradually. The area near Ocala has a high value and is not on the market.

Results of mechanical analyses of samples of the soil and subsoil of this type are as follows:

Mechanical analyses of Fellowship clay loam. From 2 miles southwest of Ocala (soil 0-4, subsoil 4-36 in.).

Number	Description	Fine gravel	Coarse sand	Medium sand	Fine sand	Very fine sand	Silt	Clay
		Per ct.	Per ct.	Per ct.	Per ct.	Per ct.	Per ct.	Per ct.
260861	Soil	1.3	10.2	12.7	25.1	8.0	14.2	28.3
260862	Subsoil	.3	2.6	5.8	9.5	6.1	13.4	62.0

FELLOWSHIP SANDY LOAM.

The Fellowship sandy loam is found both as low and high hammock, but there is no essential difference in the soil conditions, except that the high hammock land now supports a growth of pine. There is, however, considerable variation throughout the type, particularly in depth of the surface soil and to some extent in texture. These variations occur within short distances. The type consists of a sandy mantle overlying mottled clays. The surface soil in most places is between 6 inches and 2 feet deep, but occasionally it is deeper. The first few inches of the surface soil usually consist of black to brownish-black sand or loamy sand rich in vegetable matter. The texture varies in places to a sandy loam. Beneath this dark surface portion the color becomes lighter, the subsurface consisting of a brownish-yellow to drab medium sand, which is frequently slightly sticky in its lower part. In some places the surface portion is gray, grayish drab, or dark gray in color in the upper part and light drab below. Cultivated fields soon assume a dull-gray or drab color on the surface and differ markedly in appearance from the surrounding gray sand of other types. The subsoil consists for the most part of a mottled drab and yellow plastic sandy clay. Generally the mottling increases with depth. Occasionally there are some streaks or mottlings of brick-red color, but, except in small spots, the red mottling is not conspicuous. On examination the drab-colored portion of the clay is found to consist mostly of clay particles and to be very stiff and plastic, while the yellow and brown colored material is sandy, showing in places, especially on the high hammocks, decomposing fragments of sandy rock. In places the clay is quite sandy, and yet very stiff, while in other places there is very little sand and the clay is stiff, sticky, and plastic. The clay is always moist, and often has a greasy feel in addition to its plasticity. The clay content, as a rule, increases somewhat with depth. In some areas the subsoil includes sandy strata throughout the heavier clay and vice versa. In road cuts the material has a characteristic dingy bluish-drab and brown mottled color. The roads when wet become very sticky, and are sometimes described as "clabber." When dry, however, they become smooth and very hard.

The Fellowship sandy loam has a larger development than any other of the Fellowship soils. While its areas are not widely distributed, they are extensive. The high hammock area lies in two bodies, one immediately south of Ocala and the other northwest of Ocala in the vicinity of Fellowship Church. The largest development of the low hammock areas of this type is east of Ocala, where it is associated with the swamp of Silver Springs Run and Dead

River Swamp. A few small areas are found in the southeastern part of the area, in Sumter County, around the swamps of Panasoffkee Lake and Withlacoochee River.

The high hammock areas have a hilly or irregular, ridgy topography, marked in part by steep slopes. The range above sea level is from 90 to 180 feet. The ridges have been eroded to some extent, gullies or draws having been washed out. The drainage waters find their way in short, intermittent branches, which end at the bottom of the slope in sink-hole ponds or in areas of porous sands. The surface admits of ready run-off, but as the surface is a sand with underlying impervious clay there is considerable seepage and these slopes are more or less wet and thus in part are not well drained.

The low hammock areas lie only slightly above the swamps, being in part semiswampy, and in depressions actually swampy. They are sufficiently wet to favor the growth of cypress. After rainy spells water stands upon the surface for considerable periods or until it can evaporate. Drainage of these areas is necessary before they can be cultivated.

The material of the Fellowship sandy loam is apparently mainly of residual origin. The rocks are believed to have consisted mainly of sandstone and argillaceous rocks, along with some limestone. Weathering has not been complete, as some rock fragments are found. In small spots are found quantities of sandy rock fragments varying from a grayish to brownish color, some of which are evidently ferruginous. There are also some outcrops on the surface, which, with the loose pieces, are sufficient to make the soil unfit for cultivation, but this condition occurs only over a few square rods. There occur in the low hammocks, also, rock outcrops and loose fragments of stone.

The larger part of the Fellowship sandy loam is in forest. It supports both a hardwood and a pine growth. The low hammocks have in part a mixed growth, there being scattering longleaf pine and some shortleaf pine among the hardwoods. The hammock growth is heavy, the trees being large and the undergrowth in places very thick. Live oak and water oak are most common, with some white oak, red oaks, magnolia, holly, bay, hickory, ash, and gum. Conspicuous among the trees is the large cabbage palmetto. In swampy depressions cypress is found. Some parts are covered by open pine woods, there being no undergrowth, except broom sedge or wire grass, the latter on the better drained parts. Often where pine is found it is second growth, the land having been cultivated and later abandoned and allowed to reforest itself. A considerable area of the high hammock land has at some time in the past been cultivated, but it, too, has reverted to forest, and pine has taken possession of it. The greater part of the high hammock is covered with pine, some areas with longleaf and others with shortleaf pine. The longleaf and shortleaf pines are also intermingled on some areas. There is also some hardwood growth on these higher areas, particularly in the draws. The pine-woods areas are called hammock land because it is said they originally supported a hardwood growth, the pine representing a second growth.

The growth on the high hammocks is also heavy. The oak trees are large. The pine growth is very thick and grows to a good height and size. Broom sedge takes possession of old fields.

Before the freeze of 1895 a considerable acreage of the high hammock, as well as of the low hammock land, was planted to citrus fruits, this being regarded as especially good soil for oranges, but after the freeze the lands were abandoned, and the groves were not reestablished.

The Fellowship sandy loam is considered one of the strong, productive soils of the area and is adapted to the general farm crops and to some of the special trucking crops. All the type, including the high hammocks, needs artificial drainage. The high hammocks would be greatly improved by tiling, this not only removing water quicker than it is now accomplished, but aerating the soil as well.

While this soil is largely forested and relatively little cultivated, it has a high value and is not on the market.

The average results of mechanical analyses of the soil and subsoil of the Fellowship sandy loam are given in the subjoined table:

Mechanical analyses of Fellowship sandy loam. Nos. 260839-260840 *from* 3 *miles northeast of Silver Springs* (*soil* 0-6, *subsoil* 6-36 *in.*); *Nos.* 260849-260850 *from* 2 *miles east of Silver Springs* (*soil* 0-10, *subsoil* 10-36 *in.*); *Nos.* 260855-260856 *from* ¼ *mile east of Fellowship* (*soil* 0-15, *subsoil* 15-36 *in.*).

Number	Description	Fine gravel	Coarse sand	Medium sand	Fine sand	Very fine sand	Silt	Clay
		Per ct.	Per ct.	Per ct.	Per ct.	Per ct.	Per ct.	Per ct
260839, 260849, 260855	Soil	0.8	9.2	19.5	37.4	18.2	10.8	4.5
260840, 260850, 260856	Subsoil	1.0	5.1	12.4	26.1	11.8	8.1	34.4

FELLOWSHIP FINE SANDY LOAM.

The Fellowship fine sandy loam is similar in all respects to the Fellowship sandy loam, except that it averages finer in texture. The surface soil ranges in depth from 6 inches to 2 feet or more, the variation occurring frequently within short distances. Typically the upper few inches of the surface soil consist of a black to brownish-black fine sand to loamy fine sand, more or less mucky, owing to the high content of organic matter. In places the texture varies to a light fine sandy loam. Below this the color gradually changes to a drab, brownish drab, and sometimes slightly yellowish drab. When cultivated the material becomes lighter in color as the organic matter is depleted and the soil assumes a peculiar drab or grayish color. The subsurface material varies from a fine sand to loamy fine sand, with occasionally a layer, 2 or 3 inches thick, of fine sandy loam between the soil and subsoil. The subsoil consists of a plastic clay, usually more or less sandy, but occasionally containing little sand. The color is bluish drab, becoming lighter with depth and mottled with different shades of yellow and brown. This mottling usually increases somewhat with depth, but drab is always the predominating color. On the high hammock areas there are found small patches that contain considerable quantities of sandstone fragments of brownish color. There are also some spongy or porous fragments apparently representing partially weathered calcareous sandstone from which the calcareous matter has been dissolved. The fragments vary in size from small pieces to blocks several inches in diameter. On the low hammocks, as well as upon the high hammocks, there are also occasional outcrops of the underlying rock.

The Fellowship fine sandy loam is found in a number of areas scattered through the fine-textured soils. It occurs in the high hammock section west of Martel and in areas along the Withlacoochee River. Like the Fellowship sandy loam, it is found in both low and high hammock areas. The low hammocks are associated with the swamps and are very little above them, and in these situations the type is of semiswampy character, at times of heavy rainfall being covered with water. As it has a close, compact subsoil, the type drains slowly and is generally in a wet condition. On the other hand, the soil is found on high hammocks, representing low hills, attaining elevations up to 150 feet. The lower limit of these areas, where they merge into the surrounding sandy lands, averages about 90 feet above sea level. The slopes are long and smooth, though somewhat dissected by gullies or ravines. The high hammock areas have good surface drainage. However, the subsoil is close and impervious and much of the land is kept wet by seepage.

The material is largely of residual origin, derived from the weathering of rock probably consisting of limestone and sandstone.

The low hammock areas support a hardwood growth consisting of live oaks and water oaks of large size, with hickory, magnolia, and some other trees. The higher land is mostly forested with longleaf pine and with sweet gum in the open places. The ravines in the high hammock areas have a hardwood growth, and originally all these higher lands supported a hardwood growth. The pine trees here stand thick and grow very tall.

The low hammock lands are not in cultivation. In the past there were some orange groves on them, but since the freeze of 1894-95 they have been abandoned. Areas in the high hammocks are cleared and cultivated to the general farm crops. Average yields are obtained. Corn and oats do the best. Broom sedge takes the old fields. Some of the land was in orange groves, but these were abandoned after the freeze and the land allowed to revert to forest, the growth now consisting mainly of second-growth longleaf pine and some shortleaf pine.

The average results of mechanical analyses of samples of the soil and subsoil are given in the accompanying table:

Mechanical analyses of Fellowship fine sandy loam. Nos. 260841-260842 *from* 1 *mile west of Fellowship* (*soil* 0-8, *subsoil* 8-36 *in.*); *Nos.* 260843-260844 *from* 2 *miles north of Leroy* (*soil* 0-10, *subsoil* 10-36 *in.*); *Nos.* 260845-260846 *from* 1¼ *miles north of York* (*soil* 0-12, *subsoil* 12-36 *in.*); *Nos.* 260847-260848 *from* 6 *miles north of Coleman* (*soil* 0-10, *subsoil* 10-36 *in.*).

Number	Description	Fine gravel	Coarse sand	Medium sand	Fine sand	Very fine sand	Silt	Clay
		Per ct.	Per ct.	Per ct.	Per ct.	Per ct.	Per ct.	Per ct.
260841, 260843, 260845, 260847	Soil	0.4	5.2	12.9	52.7	18.9	5.4	4.5
260842, 260844, 260846, 260848	Subsoil	.2	3.1	8.2	35.4	14.6	4.1	34.1

FELLOWSHIP CLAY.

The surface soil of the Fellowship clay consists of not more than 4 or 5 inches of sand, loamy sand, or sandy loam of black color in the immediate surface, and brownish gray beneath. In many places the surface soil is quite mucky. Over much of the type the clay comes to the surface, and even where present the sandy mantle is so shallow that when plowed enough clay would be brought up to make the land a clayey soil. The subsoil consists of a heavy clay, stiff, close-structured, more or less plastic, and of a "gumbo" or sticky character, even where sandy. It also has a somewhat greasy feel. The color is usually bluish drab, mottled with streaks of different shades of yellow and brown and to some extent with red. Usually the mottling increases with depth and the red becomes more conspicuous, but the drab color predominates throughout.

Only one area of this type was mapped. This is found northeast of Silver Springs on a low hammock extending out of the area on the northern boundary. It is low and flat and in large part semi-swampy, and during wet spells it is likely to be covered for some time with standing water. Owing to its heavy vegetation and the close structure and low-lying position of the subsoil it drains slowly. The tree growth is large, consisting of live oak, water oak, white oak, and possibly other varieties of oak, hickory, magnolia, cabbage palmetto, and some other trees, including a scattering of longleaf and shortleaf pines. Depressed areas support some cypress. The large cabbage palmetto is particularly conspicuous in this forest growth. Broom sedge makes a heavy growth, as do some other grasses and sedges.

The soil is residual, but the exact character of the parent rocks could not be ascertained. It is probable that the material is from rotten limestone and sandstone or arenaceous limestone.

None of this soil type is cleared. In its present undrained condition its value lies mainly in its forest growth, which at present is being removed and used by veneering mills in the manufacture of shipping crates. It also forms good range land for stock, especially hogs, because of the large quantity of mast from the oaks.

In order that this land may be cultivated it will be necessary to drain it thoroughly, and whether this can be done economically is a question for decision by a competent engineer. If drained, it would no doubt be a strong, productive soil. Cabbage, oats, and grass crops should succeed. On a closely related soil with a somewhat deeper sandy mantle Johnson grass makes large yields. Owing to its heavy tree growth, the type is difficult and expensive to clear. In its present condition it is valued at about $15 an acre, but at this price there is little on the market.

Results of mechanical analyses of samples of the soil and subsoil of this type are given below:

Mechanical analyses of Fellowship clay from 2 miles northeast of Silver Springs (soil 0-4, subsoil 4-36 in.).

Number	Description	Fine gravel	Coarse sand	Medium sand	Fine sand	Very fine sand	Silt	Clay
		Per ct.	Per ct.	Per ct	Per ct.	Per ct.	Per ct.	Per ct.
260835	Soil	0.3	7.5	13.4	34.8	15.9	16.4	11.8
260836	Subsoil	.5	3.3	7.3	15.9	7.4	11.3	54.3

FELLOWSHIP SAND.

The surface soil of the Fellowship sand to an average depth of 8 inches varies from a black to brown loamy sand to a brownish-gray medium sand. The subsoil to a depth of 3 feet or more continues as a dark to light-drab colored medium sand, the upper portion being slightly brownish in places. The color becomes lighter with depth and frequently the lower subsoil is somewhat sticky, containing some clay. Occasionally sandy clay is reached at 3 feet, but as a rule the depth to clay is 4 to 5 feet. This underlying clay is similar to that under the Fellowship sandy loam, being a drab-colored sandy clay, slightly mottled with yellow and brown. The lower subsoil is usually saturated with water, the underlying clay being somewhat impervious.

The Fellowship sand is of small extent, being limited to a few small areas on the higher hills south of Ocala and in the vicinity of Fellowship Church. These areas are flat and do not extend down the slopes to any extent. While they lie high, they are not thoroughly drained, because of the impervious clays beneath.

The origin of this type is not definitely known, but it is probably largely residual and derived mainly from the sandy formations associated with the Vicksburg limestones.

The Fellowship sand supports both a hardwood and a pine growth. The former consists mainly of different varieties of oak and magnolia. There are also some cabbage palmetto. Both the longleaf and shortleaf pine are found upon it.

Some of this soil type is cleared, but it is considered rather poor, giving only moderate yields of the different farm crops. Broom sedge and wire grass grow upon it, the better drained portions supporting a good sod of wire grass.

The average results of mechanical analyses of samples of the soil and subsoil follow:

Mechanical analyses of Fellowship sand. Nos. 260837-260838 *from* 4½ *miles southwest of Ocala* (*soil* 0-8, *subsoil* 8-36 *in.*). *Nos.* 260863-260864 *from* ⅛ *mile north of Fellowship Church* (*soil* 0-8, *subsoil* 8-36 *in.*).

Number	Description	Fine gravel	Coarse sand	Medium sand	Fine sand	Very fine sand	Silt	Clay
		Per ct.	Per ct.	Per ct.	Per ct.	Per ct.	Per ct.	Per ct.
260837, 260863	Soil	0.8	8.1	19.4	53.8	13.0	3.0	1.9
260838, 260864	Subsoil	.4	7.5	18.9	54.1	14.2	3.0	2.0

PARKWOOD CLAY LOAM.

The surface soil of the Parkwood clay loam ranges from 4 to 8 inches in depth, averaging about 6 inches. It consists of a friable clay loam, generally quite silty, but in places, especially bordering sandy lands, there may be a shallow covering of sandy material, not more than an inch or two thick. There is some variation in the color of the soil. In the wooded areas and in low spots the color is black and the immediate surface is more or less mucky, but in the cultivated fields the soil becomes brown to grayish. In the Warm Spring hammock the brown color predominates, while in the other areas the color is black to grayish. The immediate subsoil consists of a dark-yellow or light yellowish-brown clay or silty clay. This becomes lighter, almost white to ocherous yellow, with increase in depth. In higher spots in the Warm Spring hammock the upper subsoil is for a few inches a dark or rusty-red clay. The thickness of the yellow portion of the subsoil varies from an inch or two to 2 feet, but it usually occupies 6 to 15 inches of the profile section. The lower part of the subsoil either contains a noticeable amount of yellowish-white to white marl or rotten limestone material, or consists largely of white clayey marl or weathered limestone material. Quite often this marly material is near enough the surface to be reached by the plow. In such places fragments of the material are scattered over the surface and intermingled with the soil material. Throughout the type there are occasional small stony areas in which the fragments consist of flintlike limestone. These are irregular in shape and range in size from small pieces to blocks a foot or more in diameter. This limestone, before it is exposed, is very soft, but upon exposure to the air becomes very hard.

The Parkwood clay loam occurs in the southeastern part of the area, in the vicinity of Panasoffkee Lake. It is of comparatively small extent, being limited to a few small areas. The largest of these are the Warm Spring hammock, just southeast of the corporation limits of the town of Coleman, and a somewhat larger area southwest of Wildwood, in which the Monarch orange grove is located. The other areas are small spots occurring as islands in the extensive swamps of this section.

This type occupies low-lying, flat areas. All of these, with the exception of the Warm Spring hammock, occur in the swamps occupying slightly elevated islandlike situations, indicated by their hammock growth of hardwood trees in contradistinction from the swampy growth of cypress. Owing to their low-lying position they are poorly drained. The Warm Spring hammock, however, owing to its higher position and nearness to Warm Spring Run, as well as its somewhat porous substratum, has fairly good drainage. The area near Wildwood lies low, and in putting out citrus trees they are planted on mounds in order to get better drainage.

The Parkwood clay loam is residual, being derived from limestone and deposits of marl or a soft marl-like limestone.

The Parkwood clay loam is considered the best and strongest soil in the area surveyed. It is well suited to a large number of crops—that is, where it can be drained sufficiently. At Coleman it is used mainly for cabbage and tomatoes, and these products have made a reputation on the markets for their good quality. The cabbage yield ranges from 200 to 450 crates to the acre, averaging about 110 pounds to the crate. From 1,200 to 1.500 pounds of high-grade fertilizer analyzing about 5 per cent of phosphoric acid, 6 per cent of nitrogen, and 8 per cent of potash is used. It is a cottonseed meal, blood, and bone mixture, with acid phosphate and potash. The same fertilizer is used for tomatoes, the quantity generally being about 1,000 pounds to the acre, and the yield of tomatoes ranges from 250 to 300 crates. The tomatoes are said to be of first quality. They are sound and heavy, and on the average are said to bring 50 cents more per crate than tomatoes from other soils. Cabbage and tomatoes are often grown year after year on the same land, but there is in reality a rotation of crops, for the truck crops are always followed by corn, which yields, without further application of fertilizers, 50 bushels per acre. After the corn is harvested crab grass, crowfoot, and sandspur volunteer and good yields of hay are obtained. Beggarweed, when it has obtained a hold, crowds the grasses out, but it gives a heavy yield of hay and in addition is a valuable soil improver, for, being a legume, it adds to the store of nitrogen. In September, after the hay is harvested, the land is plowed again and prepared for either cabbage or tomatoes.

Beets also do well and are grown to some extent upon this soil. Onions, while grown only in small patches, yield heavily. Those areas of this soil having a rather mucky surface are especially adapted to onion growing. In the Warm Spring hammock there are about 50 acres under irrigation. The overhead system known as the Skinner system is used. While this soil, where elevated at all, because of its porous nature can absorb much water during wet seasons without becoming excessively moist, it also resists drought well. In dry seasons, however, it is found that the crops can be hastened and the yield greatly increased by irrigation.

The hammocks southwest of Wildwood and those along Lake Panasoffkee are devoted entirely to citrus fruit growing. That near Wildwood is the site of the Monarch orange grove, which is said to be one of the largest in the world, containing over 500 acres in one tract. Other areas of the Parkwood clay loam also support large groves. The trees in these groves do not receive any fertilization whatever, the soil being strong enough to produce thrifty trees and sound fruit. As these hammocks are low and adjoin swamps, the trees, as already stated, are planted upon mounds, so that they may stand above water during wet seasons. The oranges, grapefruit, and tangerines produced in these groves are of the best quality. The trees are young, however, the freezes of 1894-95 and 1899 having completely destroyed the groves, so that while a large output is obtained at present, the production, provided unfavorable seasons do not occur, will be greatly increased as the trees grow older and larger.

The Parkwood clay loam supports a heavy growth of large trees with a thick undergrowth, forming in the undisturbed forests an almost impenetrable jungle. Live oak, water oak, and white oak, hickory, magnolia, sweet gum, black gum, ash, with some cabbage palmetto and large slash pine constitute the principal tree growth.

The orange-grove properties are not on the market, and the hammock land at Coleman is worth \$250 to \$300 an acre, being the most valuable land in the area surveyed. There is rarely any change of owners, however, as the land is so desirable because of the profit to be derived from it that only under extraordinary circumstances is it disposed of. The value has increased 400 or 500 per cent in the last 10 years.

The individual holdings are small, the hammock being divided into 10-acre tracts and very few having more than this acreage. The whole area of a tract is devoted to the crops, the owners living on the sandy lands at Coleman, where the location is more healthful and the land has little agricultural value.

The mechanical analyses of typical samples of the soil, subsoil, and lower subsoil of the Parkwood clay loam are given in the following table:

Mechanical analyses of Parkwood clay loam. Nos. 260825-260827 *from* 2½ *miles southwest of Wildwood* (*soil* 0-5, *subsoil* 5-20, *lower subsoil* 20-36 *in.*); *Nos.* 260828-260830 *from* ¾ *mile southeast of Coleman* (*soil* 0-5, *subsoil* 5-18; *lower subsoil* 18-36 *in.*).

Number	Description	Fine gravel	Coarse sand	Medium sand	Fine sand	Very fine sand	Silt	Clay
		Per ct.	Per ct.	Per ct.	Per ct.	Per ct.	Per ct.	Per ct.
260825, 260828	Soil	0.6	3.4	6.5	24.9	9.8	30.2	24.6
260826, 260829	Subsoil	2.8	6.0	6.7	22.6	8.6	26.3	27.2
260827, 260830	Lower Subsoil	2.1	5.2	4.5	13.1	6.1	40.9	27.9

The following samples contained more than one-half of 1 per cent calcium carbonate ($CaCO_3$): No. 260825, 25.52 per cent; No. 260828, 5.97 per cent; No. 260829, 11.84 per cent; No. 260827, 60.95 per cent; No. 260830, 48.63 per cent.

PARKWOOD FINE SANDY LOAM.

The surface soil of the Parkwood fine sandy loam varies considerably in depth, ranging from about 6 inches to 2 feet. It varies from a light fine sandy loam to a loamy fine sand, the immediate surface usually being black and somewhat mucky, especially in wooded areas, and the subsurface dark gray to gray. The subsoil begins as a plastic yellow silty clay, containing some marl and weathered limestone material, and grades into gray or nearly white marly clay, the content of calcareous material increasing downward. There is a variation in which the surface soil is black down to the clay subsoil and contains considerable numbers of small fresh-water shells, such areas being locally known as "shell hammocks."

The Parkwood fine sandy loam is of small extent, being limited to a number of small areas in Sumter and Citrus Counties, in the region of Panasoffkee Lake and Withlacoochee River. The areas occur partly surrounding the Warm Spring hammock and on the borders of swamps and small islands in the swamps. They are low lying, flat, and barely elevated above the swamp; hence are poorly drained. The exceptions are those areas occurring along the Withlacoöchee River banks, which have good drainage.

It appears that the sandy surface soil of this type consists of sedimentary material originally unconsolidated. The subsoil is unquestionably residual from marl and limestone.

The greater part of the Parkwood fine sandy loam is cleared and under cultivation. Around the hammock at Coleman the same trucking crops that are grown on the Parkwood clay loam are grown, namely, cabbage and tomatoes, but being less productive it is not so much in favor. It has a wider crop adaptation, however. Irish potatoes and other truck crops, as well as the general farm crops, yield exceptionally well upon it. Around Lake Panasoffkee citrus fruits are grown, and, as on the Parkwood clay loam, no applications of commercial fertilizers are made.

This soil supports a hammock growth similar to that of the Parkwood clay loam, with pines encroaching upon it where it grades into the adjoining sandy lands.

The value of this land is high and it brings about as much as the Parkwood clay loam in the Warm Spring hammock. The areas around Lake Panasoffkee that are not in orange groves are less valuable because of their distance from railroads.

The average results of mechanical analyses of samples of the soil and subsoil of the Parkwood fine sandy loam are shown in the following table:

Mechanical analyses of Parkwood fine sandy loam. Nos. 260833 *and* 260834 *from* 2 *miles west of Coleman (soil* 0-10, *subsoil* 10-36; *Nos.* 260851 *and* 260852 *from* 2 *miles east of Carlson Ferry (soil* 0-12, *subsoil* 12-36 *in.).*

Number	Description	Fine gravel	Coarse sand	Medium sand	Fine sand	Very fine sand	Silt	Clay
		Per ct.	Per ct.	Per ct.	Per ct.	Per ct.	Per ct.	Per ct.
260833, 260851	Soil	0.1	6.0	20.7	53.5	11.6	5.6	2.4
260834, 260852	Subsoil	.2	4.3	16.9	40.6	9.1	9.3	19.4

The following samples contained more than one-half of 1 per cent calcium carbonate ($CaCO_3$): No. 260834, 16.09 per cent; No. 260852, 12.68 per cent.

LEON SAND.

The Leon sand is the typical soil of the scrub palmetto flatwoods, though it includes a hammock phase when considered from the standpoint of vegetation. The texture and structure of the soil material are identical in the scrub and hammock areas. It also occurs in the sand ponds or depressed basins. Typically the soil consists of gray to white medium sand, somewhat compact but incoherent where cultivated, 36 inches or more in depth. The gray color of the surface is the result of a slight admixture of organic matter. In places along the contact with Portsmouth soils the surface is often dark. A characteristic feature of the type is the speckled or salt-and-pepper appearance of the surface, caused by specks of organic matter intermingled with the soil grains and, to some extent, the staining of the soil grains themselves with organic material. Beneath the gray or grayish-white surface the sand is generally white, though in places a slightly yellowish or brownish tinge is found. There is usually encountered within the soil profile of 36 inches, as a rule from about 20 to 30 inches beneath the surface, a brown-colored compact stratum of sand. This material resembles coffee grounds. It is darker in the upper portion, gradually becoming lighter below. Underneath is found water-saturated white or slightly drab-colored medium sand, extending to the underlying limestones of the region. The thickness of this compact brown layer varies from a few inches to a foot or more. This layer is locally known as "hardpan." When wet it is penetrated without difficulty by the soil auger, but when dry it becomes hard, and, at least in places, will obstruct the growth of the roots of plants and trees. The brownish material giving rise to the compactness of the layer consists of organic matter, with some compounds of iron. Observation discloses the fact that it is formed at or under the permanent water-table level.

The Leon sand is found in the eastern half of the area, where it occupies the flat situation known as "scrub palmetto flatwoods." The tree growth is mainly longleaf pine and in places shortleaf pine, the trees being generally stunted and sparse. Its characteristic undergrowth is scrub saw palmetto, with some gallberry bushes, grasses, and sedges. These flats occur along the larger streams and lakes. One area lies in the vicinity of Silver Springs Run, but the largest development of this phase is in the Withlacoochee Valley, east of the river and around Lake Panasoffkee, in the vicinity of Coleman. The elevation of these flats is 50 to 60 feet above sea level. While generally flat, they occasionally show some slight undulation, caused by trough depressions or depressed basins and by sink-hole ponds. Here and there, especially in the southern part of the area, some rock outcrops are found, consisting of the flinty part of the underlying limestones.

There is some variation in the type where it occurs in the hammocks, the soil being darker than in the flatwood areas, owing to a greater proportion of organic matter. Also, the hardpan substratum is of less frequent occurrence, being found only in small spots and is deeper or entirely absent in the soil profile. In some places the material lies directly upon rock. The tree growth on these hammocks consists of live oak and water oak, magnolia, cabbage palmetto, and some other hardwoods. The largest hammock areas are found in basins in the "high hammock" land, which are spoken of as "sand scrub." The tree growth here is large, owing in part either to nearness of the underlying clays or to the good moisture conditions. Flinty rock outcrops are frequent. Some hammock growth is also found forming rims around ponds in the pine-woods areas.

A phase of this type occurs in the ponds and prairies shown on the topographic base as intermittently wet areas and locally called "sand ponds." The sand mantle here is gray or dark gray and is underlain at a few inches by a brown "hardpan layer." These ponds are very leachy, holding water only a short time. Dog fennel is the principal growth. These depressions occur in the flatwoods area and in the basins in the rolling sandy lands. The material constituting this soil undoubtedly is derived directly from originally unconsolidated Coastal Plain deposits.

The Leon sand is generally recognized as a very poor and undesirable soil. The hardpan stratum seems to prevent or check the movement of water either down or up. During rainy spells the water is held in the upper portion, and as the land lies low it is very often covered with water. This water can escape by lateral seepage and by evaporation, only the latter being probably the most effective means of removal. On the other hand, when the dry season comes, which is in the winter and early spring, the soil becomes very dry and will not support growing crops. This hardpan stratum, however, in some of the developed trucking sections of the State, is said to constitute a valuable feature, in that it tends to hold up irrigation water in such a way as to make the artificial application of water cheaper and more effective. Heavy applications of nitrogenous, phosphatic, and potassic fertilizers have to be made in order to produce good yields. Organic matter should be supplied by adding barnyard manure, where obtainable, or by turning under some leguminous crop, such as cowpeas, velvet beans, or beggarweed. With the incorporation of sufficient quantities of organic matter and commercial fertilizers this soil can be made to produce a number of trucking crops, such as lettuce, celery, and potatoes. On some of the better Leon sand outside of this area cucumbers are grown with profit. None of the type is cleared and under cultivation within this area. It has a very low value.

LEON FINE SAND.

The Leon fine sand is similar in all respects to the Leon sand, with the exception that the texture is fine instead of medium. It occurs in association with fine-textured soils in the western half of the area. The type consists of fine sand to a depth of 36 inches. The surface portion is gray to almost white, and the subsoil almost white, except for a brown layer of "hardpan" which is usually present somewhere in the 3-foot section. Beneath the hardpan is found white or slightly drab-colored sand saturated with water. Like the Leon sand, the material is somewhat compact in places, but upon handling it becomes incoherent. The texture is uniform throughout the 3-foot section, but there is slight variation in texture from place to place as it tends either toward a coarser or a finer texture. In places along the border with Swamp or the Portsmouth soils it is considerably darker here, approaching the character of the Portsmouth soils.

The Leon fine sand occupies extensive areas of palmetto flatwoods along the Withlacoochee River and in the Lake Tsala Apopka section. In the latter development it occupies flats standing only slightly above the waters of the lake or which extend into the shallow parts of the lake and are covered by water only during the wet season. In the Tsala Apopka Lake section there are also areas supporting a hammock growth of water oak and live oak, magnolia, and other hardwood trees and shrubs. The flatwoods support a thick growth of scrub saw palmetto, with some gallberry on the poorly drained spots, and broom sedge and wire grass on the better drained areas. The tree growth consists of shortleaf pine having a stunted appearance and frequently gnarly and twisted tops. There is a considerable area of this soil in the shallow ponds and prairies which hold water only during wet periods, at other times being entirely dry, and which support a characteristic growth of dog fennel, with some grasses and sedges. These areas are indicated by symbol.

The Leon fine sand is considered a poor and undesirable soil. It is too wet during rainy seasons and too dry in dry seasons. Because of the finer texture of this soil it is a somewhat better soil than the Leon sand.

To insure success with crops on this land, irrigation is necessary, and with the methods of subirrigation in vogue in some parts of the State* by the use of tiles, which bring a supply of water as required and at other times afford drainage, agriculture, especially the production of special crops, could be made profitable. In addition to irrigation and drainage, however, success would depend upon the incorporation of a good supply of organic matter in the soil and the liberal use of complete commercial fertilizer or barnyard manure. A great variety of crops could be produced. Lettuce and celery are grown on similar soil in other sections of the State, also cucumbers, strawberries, and some other special crops. A little of the land is cleared and cultivated to the general farm crops, but the yields are low. There are areas along the Withlacoochee River that could be drained readily and irrigated, though probably artesian water could not be obtained. At present most of this soil is too far from the railroads to make the growing of special crops practicable and its value is very low.

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*See Circular No. 21, Bureau of Soils. This circular discusses briefly the uses and value of subirrigation in the trucking section about Sanford, Fla.

PORTSMOUTH SAND.

The surface soil of the Portsmouth sand consists of 8 to 18 inches of a black, loamy sand, high in organic matter, having in places almost the characteristics of muck. This changes abruptly into a drab or drabbish-gray to white sand, 36 inches or more in depth. In places a layer of brown sand, resembling coffee grounds, is encountered at varying depths. This layer represents the "hard-pan" stratum so common in Florida soils. The subsoil is always in a water-soaked condition. The sand is rather compact in its natural position, but is incoherent when disturbed, and, like the subsoil of the Portsmouth fine sand, tends to flow when dug into in a way resembling a quicksand.

The areal extent of the Portsmouth sand is small compared with that of other types. It occurs in small areas scattered throughout the eastern part of the area, associated with the other soils of medium texture, being confined to depressed situations in the flat-woods; to sink-hole or basin depressions in the higher lands; and to the lakes and prairies of the area. These areas are all wet a large part, if not all, of the year. This condition favors the accumulation of organic matter on the surface, and is in contrast with other ponds or depressions, known as "sand ponds" that do not hold water long, and thus do not afford conditions favorable for the accumulation of organic matter.

The Portsmouth sand is derived from unconsolidated sedimentary Coastal Plain deposits. The dark-colored organic matter represents simply the decomposing remains of vegetation.

As this soil lies so that it is wet much of the time, and lacks drainage, it affords very little land for cultivation. Much of it would be difficult or impossible to drain economically. There are, however, some small areas in cultivation. Where it can be drained, either by ditches or tiles, fairly good results with certain vegetables may be expected. This same soil in developed sections of the State is successfully used for crops like celery, lettuce, cucumbers, and strawberries, but only a few small areas have been utilized in this survey. Those areas where drainage is practicable would warrant being put in condition for cultivation. This soil, wherever it occurs, is found to be sour or acid, and liming is necessary before it can be made to produce crops that do not thrive in acid soils. Under cultivation this soil, especially where given clean cultivation, soon loses much of its organic matter by oxidation. Thus it is advisable to keep it in some cover crop, or allow the weeds to grow. Barnyard manure is beneficial to this soil, and for producing the special trucking crops fertilizers are necessary. Because of its poor drainage and lack of development, this soil has a low value.

The natural vegetation varies. In ponds and prairies the grasses thrive, including saw grass, sword grass, broom sedge and other sedges, and aquatic plants. There is plenty of forage produced, so that these lands are held in some esteem as pasture. Some of the areas support a growth of cypress, with other hardwood trees in the less swampy places.

PORTSMOUTH FINE SAND.

The surface soil of the Portsmouth fine sand to a depth of 10 to 15 inches consists of a black loamy fine sand to mucky fine sand, high in organic matter. This is underlain by compact drab or gray water-soaked fine sand. When bored into, the sand runs into the auger holes, showing that the subsoil flows on the order of quicksand when exposed. This tendency makes it difficult to dig effective ditches. In places there is found the brown "hardpan" layer of fine sand like that of the Portsmouth sand. The type grades into the Leon soils on the higher positions in such a way that sharp boundaries could not always be drawn.

The Portsmouth fine sand has a considerable development in the area, being found in a number of bodies along the Withlacoochee River and the Tsala Apopka Lake section. It is also found in small areas in the shallow lakes or prairies occurring in the Norfolk fine sand in the western part of the area.

The Portsmouth fine sand is a low-lying soil, occurring in association with the swamp and lakes. It is flat and poorly drained. The water table is near the surface, and the subsoil is always saturated. The surface is frequently covered by water during rainy spells. Some bodies of this type occur in swampy areas, while a good deal of it is found in the shallow lakes or prairies and ponds or sinks. An area east of Dunnellon occupies a flatwoods section that is dotted with numerous shallow grass ponds or prairies.

The Portsmouth sand supports a variety of vegetation in its different areas. In the ponds or prairies are found water-loving grasses and sedges. Saw grass, sword grass, water lilies, and some other aquatic plants flourish in the shallow water-covered areas. The less frequently water-covered treeless areas support a heavy growth of broom sedge, as well as other sedges and grasses. There are some bodies that have a growth of water-loving trees, such as cypress, gum, magnolia, bay, cabbage palmetto, and others. In its lower-lying positions it also occupies flatwoods areas, which are distinguished by the sparse and rather low growth of longleaf and shortleaf pine and an undergrowth of gallberry bushes. The scrub palmetto also occurs, but is not prominent except on the higher parts. This latter growth is more characteristic of the associated Leon soils. Besides gallberry, broom sedge flourishes, as well as some other grasses and sedges. Areas of the type where the pine is removed are commonly referred to as "gallberry flats" and "flatwoods."

Largely because of its low-lying position and poor drainage, none of the Portsmouth fine sand is cleared and under cultivation. The depressed areas in ponds and along swamps would be difficult, if not impossible, to drain. The flatwoods areas, while being only slightly above the depressed areas, might possibly be drained. This type of soil, thoroughly drained, would prove valuable for a variety of crops, not only general farm crops, but truck crops. For the latter it is especially well adapted. It is upon this class of soil that much of the trucking is done in the State. Celery, lettuce, onions, strawberries, cucumbers, and some other crops would do well. In addition to being drained, this land would require irrigation to insure success, as vegetable growing is done during the dry season. Where drainage is practicable it would certainly be advisable to develop the agricultural possibilities of this soil type. Rather liberal applications of complete fertilizer mixtures would be necessary for good yields. Liming would also prove beneficial.

The present value of this land is low, and there is no demand for it on the market.

SWAMP.

Swamp includes those low-lying areas that are more or less covered by water throughout the year and support a growth of water-loving trees. These are mainly cypress, but gums and other species are found. In hammocks in the Swamp magnolia, bay, hickory, and cedar are found, but in the larger and wetter swamps cypress is almost the only growth, many of the trees being of great size. The extent of Swamp is considerable, the largest areas being along the Withlacoochee River and around Lake Panasoffkee. There is also an area bordering Silver Springs Run and connecting with the Dead River Swamp, on the northeast boundary of the area.

The Swamp is the lowest-lying land in the area. The elevation lies between 40 and 50 feet above sea level. The Swamp owes its occurrence to the sinking of the land resulting from the solution of limestone.

Drainage over most of the type would be very difficult and expensive, if not impossible. When the streams are at the high-water stage the swamps are covered by water, but during dry seasons the immediate surface may be entirely dry.

The soil of the Swamp varies considerably, as might be expected. As a general rule, however, the surface is mucky to some depth. In places the underlying clays are found near the surface. They are of drab or bluish to dark color and often mottled, ranging from stiff plastic clay to heavy sandy clay. In places a compact white or drab sand is encountered beneath the mucky surface material.

Swamp, marl subsoil phase.—A part of the Swamp is underlain by marl. Around Lake Panasoffkee the profile consists of muck underlain by shell marl, and some of the Swamp along Silver Springs Run is of the same character, though no attempt was made to differentiate such areas in the latter section. Low hammocks of marly character in the Swamp along Withlacoochee River support a growth of cedar and are known as cedar hammocks.

The mineral soil material of the Swamp, particularly the clay, is in part residual from limestone, marl, and shell beds. Deposits from the stream flood waters have been added. The mucky surface is from the partial decay of the heavy vegetation growing in the swamps.

The cypress trees constitute the main value of the Swamp, but during the dry season the land affords good range for hogs. It has no present agricultural value.

SUMMARY.

The Ocala area is situated in the north-central part of the Florida peninsula and comprises an area of 1,002 square miles, or 641,280 acres. It includes parts of the counties of Marion, Sumter, Citrus, and Levy. It forms an elevated portion of the peninsula and is underlain by limestone.

The topography is varied, ranging from low and flat areas in the swamps and flatwoods to rolling in the sandy hills and high hammocks. The highest point in the area is 220 feet and the lowest 20 feet above sea level. A marked feature of the topography is the sinkholes and depressed areas and the general lack of surface drainage systems, the drainage waters passing downward through the porous soils.

The area drains into both the Gulf of Mexico and the Atlantic Ocean. The Withlacoochee River passes through the area in its central part, flowing northwest and emptying into the Gulf. On the northeast the Silver Springs rise from subterranean channels and flow east to the Ocklawaha River, emptying into the St. Johns River, which in turn empties into the Atlantic Ocean.

Settlement began prior to 1850, but the extension of settlement has been slow, and the rural population is still sparse. The early settlers were from Georgia and North and South Carolina. In recent years numbers of settlers have come from the Northern and Western States.

The railroad facilities are exceptionally good, both the Atlantic Coast Line and Seaboard Air Line Railroads passing through the area. These are main trunk lines. In addition to these are the Ocala Northern and Ocala Southwestern Railroads. Water transportation is afforded by Silver Springs Run and the Ocklawaha and St. Johns Rivers. There is also local water transportation on a part of the Withlacoochee River and Panasoffkee Lake. The county roads are numerous. They are being rapidly improved, and there are many miles of stone and clay surfaced roads.

Ocala, the county seat of Marion County, with about 4,500 inhabitants, is the largest town. It is an important business and railroad center. Dunnellon, Hernando, and Inverness, in the western part of the area, are towns of considerable importance in the phosphate-mining section. Belleview, Summerfield, Oxford, Wildwood, and Coleman are important towns in the eastern part of the area on the railroads. Their interests are agricultural.

The climate of the area is mild, approaching the subtropical. The mean annual temperature is 69° F. and the mean annual precipitation about 52 inches.

The early agriculture was restricted to the growing of the subsistence crops and sea-island cotton, along with stock raising. After the Civil War citrus-fruit growing was taken up, which industry was almost entirely abandoned when the trees were killed by the freeze of 1894-95. Since 1890 phosphate mining, turpentining, and lumbering have been important industries. Aside from these the agriculture, while not developed over the whole area, consists in the production of general field crops, truck crops, and citrus fruits. Corn, oats, sweet potatoes, sugar cane, and velvet beans are the principal general crops, while cabbage, tomatoes, watermelons, cantaloupes, and cucumbers are the trucking crops. With the exception of the growing of cabbage, the trucking industry is of recent growth. The production of citrus fruits in the southern part of the area is being revived to some extent.

Exclusive of Swamp, 17 types of soil, included in six series, were separated and mapped.

The Portsmouth and Leon soils, each having two types, a sand and a fine sand, are found in the low-lying flatwoods. The Portsmouth types are characterized by black surface soils and drab subsoils. They require drainage and are among the best trucking soils when reclaimed. The Leon soils form the palmetto flatwoods and consist of gray to white sand, with a brown hardpan layer beneath. Without irrigation they are very poor soils.

The Norfolk sand and fine sand types are the rolling pine lands of the area. They are the gray and yellowish sands over 36 inches in depth. For the most part they are held in low esteem, but the better parts of these types make fair trucking soils, especially with overhead irrigation. They are loose and have excessive drainage.

The hammock soils fall into three series—the Parkwood, Fellowship, and Gainesville. The Parkwood soils, consisting of the clay loam and the fine sandy loam, are found on low hammocks and have marl subsoils. They constitute the strongest soils of the area and grow cabbage and tomatoes to perfection. They are also highly esteemed for citrus-fruit production and the large groves in the area are on these soils.

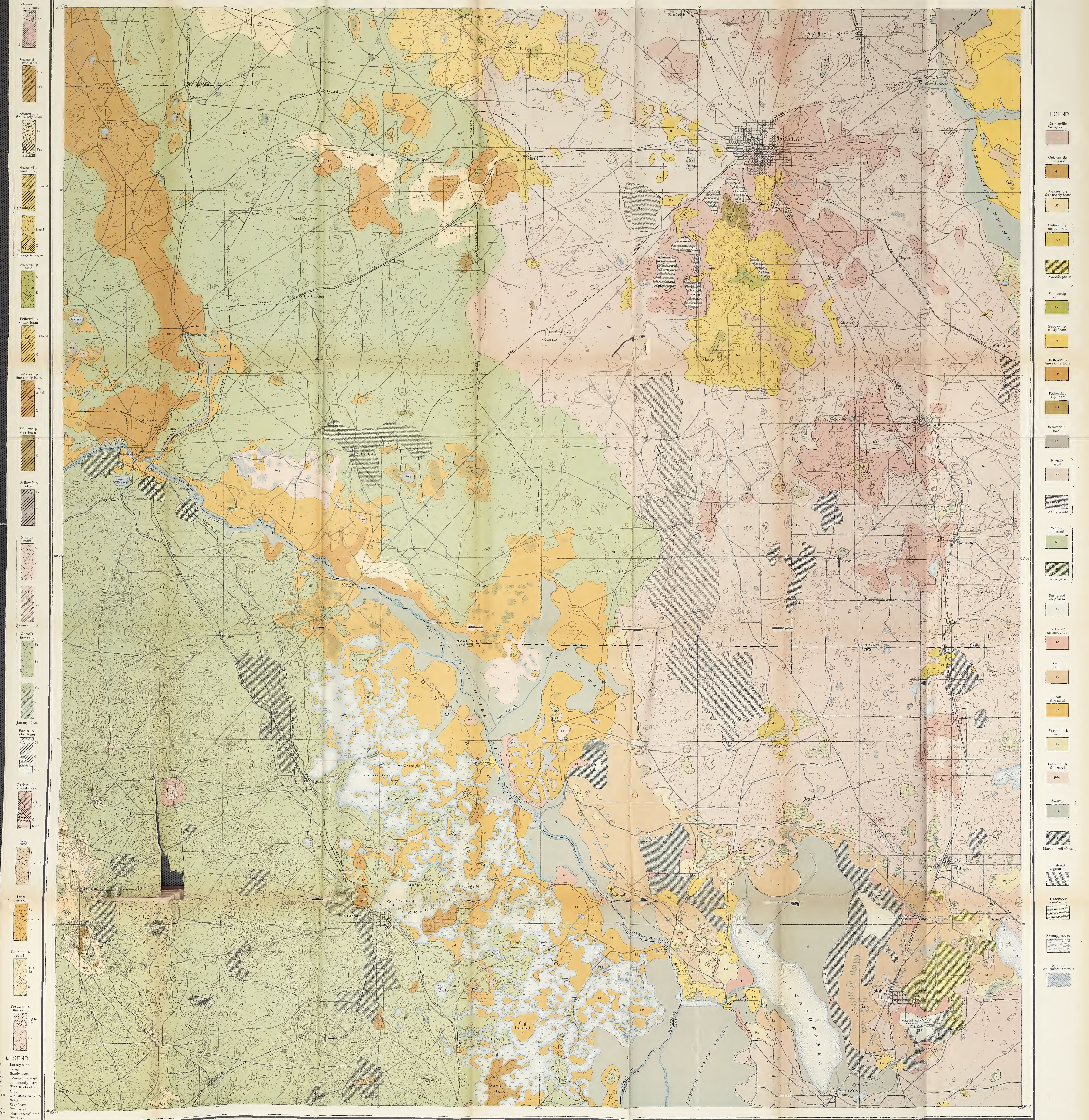
The Fellowship soils occur on both low and high hammocks, the former being in part semiswampy. With drainage these are good soils. The high hammocks support a heavy pine growth. They are adapted to a wide range of crops, but so far there is not much development on them.

The Gainesville soils occur on the high hammocks and are largely of calcareous origin. They are all well-drained, productive soils. They produce all the general farm crops and also have a wide adaptation for truck crops. Trucking is being extensively developed on these soils, especially on the Gainesville loamy sand.

U.S. DEPT. OF AGRICULTURE
BUREAU OF SOILS
MILTON WHITNEY, CHIEF.
CURTIS F. MARBUT, IN CHARGE SOIL SURVEY.

SOIL MAP
FLORIDA
OCALA SHEET

FLORIDA STATE GEOLOGICAL SURVEY
E.H. SELLARDS, STATE GEOLOGIST



Hugh H. Bennett, Inspector in charge Southern Division
Soils surveyed by Charles N. Mooney, and W. J. Latimer, of the U.S. Department of Agriculture and Herman Gunter, and Emil Gunter of the Florida State Geological Survey.

BASE MAP FROM
U.S. GEOLOGICAL SURVEY SHEETS
WITH ADDITIONS AND CHANGES

Scale $\frac{1}{62500}$

Contour interval 10 feet.
Datum is mean sea level

A. Hoen & Co. Lith. Baltimore, Md.

Field Operations
Bureau of Soils
1912

The climatic conditions in the area are such that the growing season is very long, some hardy crops being grown during the winter, with protection at times from frost. A succession of crops amounting to a rotation is thus permitted. Corn or cowpeas follow the trucking crops. After corn the volunteer growth of crab grass, crowfoot grass, sandspur, or beggarweed follow and are cut for hay.

Development of the agricultural resources of the area can be said hardly to have been begun. There is opportunity for profitable agriculture along all the lines discussed in this report.

SOIL SURVEY OF BRADFORD COUNTY, FLORIDA.

BY

W. C. BYERS, ARTHUR E. TAYLOR, J. B. R. DICKEY, AND
N. M. KIRK.

U. S. DEPARTMENT OF AGRICULTURE,

BUREAU OF SOILS—MILTON WHITNEY, CHIEF.

IN CO-OPERATION WITH THE FLORIDA STATE GEOLOGICAL SURVEY;
E. H. SELLARDS, STATE GEOLOGIST.

HUGH H. BENNETT, INSPECTOR, SOUTHERN DIVISION.

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MAP.

Soil map, Bradford County sheet, Florida.

SOIL SURVEY OF BRADFORD COUNTY, FLORIDA.*

By W. C. Byers, Arthur E. Taylor, J. B. R. Dickey, and N. M. Kirk.

DESCRIPTION OF THE AREA.

Bradford County lies in the northeastern part of Florida. It is irregular in shape and is bounded on the north by Baker County, on the east by Clay County, on the south by Alachua County, from which it is separated by Santa Fe Lake and the Santa Fe River, and on the west by Columbia County, the western boundary being formed by Olustee Creek. The county has a maximum width of about 30 miles from north to south, and a length of 32 miles from east to west. It has a total area of 539 square miles, or 344,960 acres.

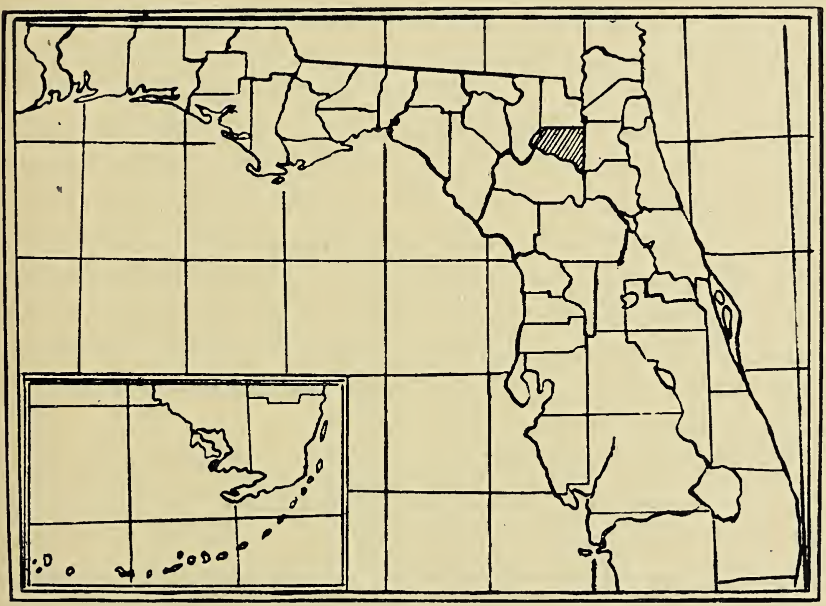

Fig. 71.—Sketch map showing the location of Bradford County.

Bradford County lies wholly within the Coastal Plain. The divide between the Gulf and the Atlantic Ocean is just a few miles east of the east county line, swinging around a few miles north of the north county line. The range in elevation within the county is about 140 feet, or from about 60 to approximately 200 feet above tide. The drainage is toward the south and west. The county is drained by the Santa Fe River and its tributaries, including mainly Alligator Creek, Sampson River, New River, and Olustee Creek, with their numerous branches. All of these streams flow in either a southern, western, or southwestern direction.

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Some sections of the county have well-defined drainage systems. Much of the flat country, however, is inundated during seasons of heavy rainfall, and cypress ponds, bays, and swamps remain filled with water for long periods.

The northern and eastern parts of the county lie almost entirely within the flatwoods region. The topography of this section is flat to gently undulating, with but a few slight surface variations. As the larger streams are approached the surface becomes gradually more undulating and in places even rolling to hillocky, with relatively deep, narrow, well-defined valleys. The highest elevations are in the northeastern part of the county. The country along the larger streams, notably the Santa Fe River, the New River, Olustee Creek, and Swifts Creek near its confluence with Olustee, has a more rolling topography, including ridges which in places terminate with a bluff along the streams. In this section the valleys are narrow, and the numerous smaller streams or "branches" which work back into the uplands from the larger streams give the country a decidedly billowy surface.

Farther back from the larger streams, beyond the heads of the tributary streams, the country has a more nearly level topography, difference in elevation between the stream courses and the crests of the divides being barely perceptible. As this country is approached the floors of the stream valleys rise gently until they approach the general level of the upland, their power of erosion lessening until they become almost negligible in altering the level topography. The stream valleys are therefore shallow, and it is difficult in many cases to determine the extent of the overflow land, owing to the gradual merging of the bottoms into the upland. In some cases the prevailing surface has so slight an elevation above that of the stream courses that the water spreads out from the stream channels in places over large expanses of the surrounding country, forming "swamps" which support a luxuriant growth of subtropical water-loving vegetation. With but few exceptions, the stream channels are not well defined, and frequently a stream course has two or more channels, while during seasons of protracted rainfall the water covers the entire valley floor. The streams generally head in "bays" or swamps and in their upper reaches are merely drainage ways or wet-weather streams.

Bradford County was formed from Alachua and Columbia Counties in 1858. It was originally known as New River County, the name being changed to Bradford County in 1861. The county seat was moved from Lake Butler to Starke in 1887.

The population of Bradford County in 1890 was 7,516, in 1900, 10,295, and in 1910, 14,090. Starke, with a population of 1,135, is the largest town in the county. It is situated on the Seaboard Air Line Railway in the eastern part of the county, and about 45 miles from Jacksonville. It is one of the most important points of strawberry shipment in the State. Lake Butler, the former county seat, is situated near the center of the county. Its population is given in the 1910 census as 685. It is also an important shipping point, owing to its location on both the Atlantic Coast Line and Georgia Southern & Florida Railroads. Lawtey, with a population of about 500, is on the Seaboard Air Line Railway in the northeastern part of the county. Considerable shipments of strawberries take place at this town. Hampton, on the Seaboard Air Line and Georgia Southern & Florida Railroads; Raiford and Worthington, on the Atlantic Coast Line; and Brooker, on the Wannee Branch of the Seaboard, are towns of less importance.

Bradford County is well supplied with means of transportation. The main line of the Seaboard Air Line runs north and south through the eastern part of the county. The Atlantic Coast Line traverses the county from the north-central to the southwestern part. The Georgia Southern & Florida runs diagonally across the county from northwest to southeast, and the Wannee Branch of the Seaboard Air Line extends southwest from Starke, terminating in the adjoining county. The Tampa & Jacksonville Railway runs south from Sampson.

Wagon roads are numerous and extend into all parts of the county, but are generally unimproved.

CLIMATE.

The climate of Bradford County is practically subtropical. winters are short and mild and the summers long and hot. December, January, and February are the coldest months, and for this period the temperature averages about 56° F. The coldest weather is usually in February. There are sometimes traces of snow, though measurable quantities are practically unknown. Usually the cold weather comes in periods of two or three days' duration, followed by as many days of clear, warm weather, which generally precedes rain. Owing to the high humidity, the cold is penetrating.

July and August are the hottest months, with a mean temperature of about 81° F., but extremely high temperature is rare, and the heat is moderated by breezes which are practically continuous.

The rainfall, which is ordinarily sufficient for crop growth, is well distributed throughout the year. However, during seasons of scant rainfall crops grown upon the more sandy and better drained soils are likely to suffer from drought, while during seasons of excessive precipitation an excess of water frequently collects on the lower lying and poorer drained areas and is decidedly detrimental to plant growth.

The following table gives the normal monthly, seasonal, and annual temperature and precipitation recorded at the Weather Bureau station at Gainesville, Alachua County, Fla. In the absence of local records, these figures, compiled from data recorded at a point only a short distance to the southwest, are fairly representative of conditions in Bradford County.

Normal monthly, seasonal, and annual temperature and precipitation at Gainesville, Alachua County, Fla.

Month.	Temperature.			Precipitation.		
	Mean.	Absolute maximum.	Absolute minimum.	Mean.	Total amount for the driest year.	Total amount for the wettest year.
	Deg. F.	Deg. F.	Deg. F.	Inches	Inches	Inches
December	56.6	85	19	2.74	1.15	5.61
January	54.9	89	16	3.28	3.81	8.18
February	57.1	87	6	3.28	4.15	6.90
Winter	56.2			9.30	9.11	20.69
March	64.6	96	25	3.44	.83	3.75
April	68.5	95	38	2.36	.14	.27
May	75.8	99	47	3.79	1.75	6.63
Spring	69.6			9.59	2.72	10.65
June	80.3	102	58	7.44	2.43	11.45
July	81.4	102	60	7.48	6.89	5.91
August	81.2	99	64	7.03	7.69	10.23
Summer	81.0			21.95	17.01	27.59
September	78.0	99	48	5.86	3.98	11.62
October	70.4	95	36	2.54	1.76	4.77
November	62.5	90	22	2.10	.57	1.41
Fall	70.3			10.50	6.31	17.80
Year	69.3	102	6	51.34	35.15	76.73

The date of the last killing frost recorded in the spring is March 21, and of the first in the fall, November 13. The average date of the last killing frost in the spring is February 20, and of the first in the fall, December 11.

Plowing and other farm operations can be readily carried on throughout the year, especially on the better drained soils. Flowers bloom during the whole year, and the more hardy vegetables grow unprotected during the winter months.

AGRICULTURE.

Little attention was given to agriculture by the early settlers in this region. The western part of the county was the first to be settled. About 1835 several families came to that section of the county in which Providence is now located and engaged in stock raising.

Settlement extended into the eastern part of the county a few years later.

Cattle and hogs could live on the open range without feeding and with little attention the entire year, and it was natural that stock raising should have first claimed the efforts of the settlers and should have continued to be for some years the most important industry of the county. Small areas were cleared around the buildings, and vegetables and corn in sufficient quantities for home use were produced.

It was not until about 1855 that cotton became important. Large plantations throughout Bradford County were devoted mainly to this crop, and with its development the increasing demand for corn to feed farm stock and to supply home needs resulted in an extension of the corn crop. Agricultural progress was retarded by the Civil War, and immigration, which had been steady up to this time, was stopped. After the Civil War the agricultural development of the county was slow, and only within comparatively recent years have the resources of the county begun to be developed along broad lines. There are but few farms in the county outside of the western section that have been under cultivation for a long period of years.

Lumbering and turpentining became important about 1880. Both of these industries were developed at the expense of agriculture, although they were instrumental in clearing the land for future agricultural pursuits. At present lumbering and turpentining are the most important industries in the county. A great deal of the merchantable timber has been removed, and most of the remaining trees are "boxed" for turpentine. One large plant for the extraction of turpentine and other pine products from logs and stumps is in operation at Lake Butler. The stumps and resinous logs are being removed from land in that section of the county without expense to the owner.

About 1880 agriculture again came into importance in the county. Settlers came in from Georgia, the Carolinas, Mississippi, Kentucky, Virginia, and in some cases from as far north as Pennsylvania. Oranges were being grown extensively at this time, and a few years later strawberry growing began. The strawberries were produced for early shipment to northern markets, and the fancy prices that were obtained encouraged the extension of this industry. The culture of strawberries soon became general, and this crop rivaled oranges for the place of first importance in the agriculture of the county. In the meantime cotton, corn, and cattle had been the principal sources of income on many farms, and at present these are produced extensively, though of late years cotton has declined in importance.

Agriculture received its second reverse during the winter of 1894-95, when practically all of the orange trees in the county were killed by frost. Though not entirely dependent upon oranges as a cash crop, it was one of the main sources of support of many farmers, and the destruction of the groves resulted in great financial loss. Orange production has never resumed its place of importance in the agriculture of the county, but in all sections young trees are growing and are apparently in a healthy condition. In most cases the trees have grown from the roots of those killed by frost, though in some instances new trees have been set out. While a large number of farmers have small groves, comprising in places as many as 20 or 30 trees, to produce oranges for home or local use, the only commercial orchard where oranges are packed for shipment is in the southern part of the county near Sampson.

Strawberries have steadily grown in importance, and at present this crop forms the basis of a very large industry in the eastern part of the county. While small quantities are shipped from Lake Butler, Raiford, and several of the smaller towns, Starke and Lawtey are the centers of the berry industry. The census for 1910 gives the total value of fruits and nuts, including small fruits, produced in Bradford County in 1909 as $152,568. Since the amount of large fruits and nuts shipped from the county is practically negligible, this total amount represents the value of the berry crop. Within the last few years the strawberry industry has developed still further. According to the 1910 census, 1,353,822 quarts of strawberries were produced from a total of 699 acres in 1909.

Corn occupies the largest acreage of all the crops in the county. According to the census for 1880, less than 10,000 acres were devoted to this crop in 1879, while in 1909 a little less than 21,000 acres were used for corn production. In growing this crop the land is plowed at any time between November and February. The depth of plowing varies from 4 to 8 or more inches. Some farmers plow to a depth of about 8 inches and follow the plow with a subsoiler, which breaks the land several inches deeper without turning any of the subsoil to the surface. Deep plowing as early in the fall as possible results in increased yields, and is effective in conserving a maximum amount of the winter rainfall for the use of growing crops. Corn is usually planted between the middle of March and the first of April and is harvested late in August or early in September.

There is no system of rotation in general practice in the county, and corn often follows corn on the same land for a number of years. The yield is better when corn follows sugar cane, cowpeas, velvet beans, or peanuts than when grown after cotton or when corn has occupied the same land for several successive years.

Little or no attention is paid to seed selection, nor is any effort made to secure seed of better varieties. The "frenching" of corn has caused considerable loss during recent years. This disease attacks the corn in an entire field or a part of the field and completely destroys the crop in a very short time. It usually appears in April, and is first noticed when the corn turns pale yellow and white and the leaves begin to wilt. In its more advanced stages the roots become black, and the plant dies very much as a cowpea or cotton plant affected with "wilt." The disease is particularly prevalent over land of low fertility, and attacks crops on the well-drained sandy soils as well as upon the moister flatwoods types.

The corn land is fertilized, largely with commercial fertilizers. The available stable manure is also used. The usual corn fertilizer contains 8 per cent of phosphoric acid, 2 to 2½ per cent of nitrogen, and 2 to 3 per cent of potash. This mixture is applied at the rate of about 200 pounds per acre. Through the systematic rotation of crops, the incorporation of organic matter in the soil by plowing under green crops, and through deep plowing, some farmers have been able to reduce their fertilizer bill and at the same time secure larger yields.

Corn yields range from 5 to 35 bushels per acre, depending largely upon the method of cultivation and the treatment of the soil. Fifteen bushels is about the average yield for all of the soil in the county.

Next in importance to corn in acreage is cotton. Sea-island, or long-staple, cotton is produced exclusively, the climate being unsuited to the short-staple varieties. The 1910 census reports a total of 12,795 acres devoted to this crop, with a production of 2,998 bales in 1909. While the acreage of cotton has increased, the farmers are less dependent upon this crop as a sole means of support, there being other important cash crops, chief among which are strawberries. Cotton is grown on practically all of the upland soils, but is most productive on the Norfolk soils in the western and southwestern parts of the county.

No system of rotation is practiced wherein cotton has a place, and consequently the soils are not being improved. Large applications of fertilizers containing about 10 per cent of phosphoric acid, 2 per cent nitrogen, and 3 per cent potash are used. After cotton has followed cotton for a number of years, the land is usually put in corn for an equal period, or corn and cotton are grown alternately. When cotton follows corn, the crop does best where the soil is not disturbed below the depth of planting. The hot winds and heavy rains in July are considered the most harmful incidents in cotton production. These, it is claimed, cause the cotton to shed a portion of the young bolls, and no fertilization or cultural method has been found to enable the plant to avoid this loss. Cotton is usually planted between March 15 and April 1. The scarcity of labor and the high price demanded for picking are serious obstacles to cotton production in the county.

Cowpeas, velvet beans, and peanuts are grown extensively for forage. One or two of these legumes is usually planted in corn for use as pasture after the corn has been harvested. In this way a large amount of feed is secured for cattle and hogs during the late fall and early winter. Cowpeas and velvet beans are also grown for hay, and both make a luxuriant growth, though difficulty is often encountered in curing the pea-vine hay. The velvet beans make a more certain crop, and the vines are more easily cured. Peanuts are grown largely for hog feed or to be plowed under. The planting of a legume in corn after the last cultivation is not generally successful, and a more common and surer method is to plant such a crop with the corn. One plan that has been found profitable is to plant the corn in rows about 9 feet apart, with a row of peanuts between the corn rows. Among the peanuts velvet beans are planted in hills 6 feet apart in the row. After the corn is harvested a heavy growth of beans and peanuts furnishes an abundance of good feed for fattening cattle and hogs.

Oats are grown extensively in the county, largely for hay. Where allowed to ripen the yield of grain is about 15 bushels per acre. Various cultural methods are practiced. On wet areas the oats are sometimes drilled in rows, which are slightly ridged to afford better surface drainage. Sometimes they are sown broadcast on beds which rise above the general level of the field. On the better drained areas the oats are sown broadcast. This crop is one of the main sources of hay. It is grown by nearly all of the farmers and is cut just before the grain ripens.

A small amount of rye is also grown in much the same manner as oats, and cut for hay. Millet has recently been introduced. This crop makes a rank growth and affords an abundance of forage. Beggarweed hay is also an important forage crop, and the larger part of it is obtained from land that has already grown some other crop. Beggarweed is self-sown.

Sugar cane was one of the early crops of the county, and is still of considerable importance. Although not grown commercially, a patch is grown by nearly every farmer for the manufacture of sirup for home consumption. The varieties grown are the Red, Large Green, Cuba, White, and Ribbon. There is little noticeable difference between the several varieties, although the Red and Cuba are probably the most popular. Rice was formerly grown on a small scale, and is said to have produced an average yield of about 15 bushels per acre. The decline in its production was due to the appearance of a blight. A variety of upland rice is still grown, though the acreage is decidedly small.

Sweet potatoes are grown for home use, but have never been important commercially. They are produced on all the upland soils in the county, the yields averaging about 200 bushels per acre. Irish potatoes are grown on a small scale. Although large yields are secured, the production of this crop has never been extended to any great extent. Irish potatoes do exceptionally well on the Portsmouth fine sandy loam, the soil upon which the potato industry has been extensively developed in other localities. The crop also does well on the Norfolk soils, the Coxville fine sandy loam, and the Portsmouth fine sand. Potatoes may be planted in January, although the general practice is to plant about February 1. The early plantings are harvested in May and the later plantings and later varieties in June. The crop is usually planted on ridges in soil plowed about 3 inches deep, the seed bed having been prepared in November. The potato beetle, which does so much damage to the crop in other localities, is unknown here, but potato "wilt," or "blight," is sometimes destructive where spraying is not practiced.

More money is brought into the county from the production of strawberries than from any other agricultural source. Berries begin to ripen some seasons as early as the first of January, though shipment does not begin until February. The season is at its height during March and early April. Naturally the early shipments command the highest prices. The smaller shipments usually go in small refrigerator boxes, which are iced at starting and at various places en route in ordinary express cars. The later and larger shipments consist of carload lots, principally to Philadelphia, New York, and Boston, though some go even farther. Commission houses from the northern cities send buyers to both Starke and Lawtey, where they remain during the entire season, and either buy the berries at the cars or solicit shipments to the firms they represent for sale on commission. Seven or eight cars a day are not unusual shipments from Stark in midseason, while Lawtey sends almost as many.

Several varieties of berries are grown, though the Klondike and Missionary are by far the most popular. The Lady Thompson and Brandywine are also grown. The Missionary is a little earlier than the other varieties. The fields are prepared in slightly elevated beds, which are wide enough to accommodate two rows. The young plants which are set out for the main crop are obtained from runners set out in March or April. The main crop is set out at any time from July to October. High-grade commercial fertilizers are applied when the plants are set and at two other periods during the growth of the crop. In all, from one-half to 1 ton of fertilizer is applied to the acre. The first application usually consists of about 200 pounds. The second application is usually made in November. At this time the beds are "barred off" by plowing a shallow furrow away from the plants, but as close up to them as it is possible to run the plow without injuring the young roots. Into this furrow, which is made along only one side of the row, the fertilizer is dropped. A week later the other side of the row is treated in the same way. The last fertilization is made in January or February between the rows, from 200 pounds to 400 pounds of a mixture usually richer in potash than the mixtures formerly used being applied.

The yield and quality of the berries are mainly dependent upon the season. In seasons when the rainfall is heavy during the ripening period the berries are soft and arrive at the market in poor condition, even though comparatively large. The price received for the berries varies from $2 to $12 per crate and averages about $3.

The production of beef cattle seems to offer attractive opportunities in Bradford County. Herds of varying size are pastured over large areas of woodland, living entirely in the open and upon the native vegetation, principally wire grass. With but little effort Bermuda grass, St. Augustine grass, lespedeza (Japan clover), and Johnson grass can be grown and permanent pastures of succulent forage established. The cattle receive but little attention. The animals pastured in the woods are usually infested with ticks, and not infrequently large numbers die as a result. Those that are properly cared for and kept from the woods are comparatively free from ticks. The cattle are not dipped. Native cattle are valued at about $10 to $12 per head. Little attempt has been made to improve the breed. A few small herds of goats are kept.

Unlike almost all the other farm animals, the hogs in the county are of improved breeds, and though crosses are usually seen the typical "razorback" is uncommon.

Mules are used largely in farm work and lumbering and are of good size and quality. Horses are sometimes used for farm work, and oxen are used to a small extent in lumbering, but seldom in farming. Most of the work animals are shipped into the county.

In 1879 there were 689 farms in Bradford County, with a total of 67,572 acres, of which 22,470 acres were improved. According to the 1910 census there were 134,884 acres in farms in 1909, of which 54,255 acres were improved. The average size of farms has decreased from a little less than 100 acres in 1879 to about 85 acres in 1909, and this reduction is due largely to more intensive farming, or the change from cotton and corn farming to trucking and the production of strawberries. Only about 40 per cent of the land of Bradford County is farmed. In 1879, 594 farms were cultivated by the owners. Of the remainder, 41 were rented for cash and 54 for a share of the products. In 1909, 1,126 of the 1,587 farms were operated by the owners, 455 by tenants, and the remainder by managers. About two-thirds of the tenants rent for a share of the products and the remainder largely for cash. The value of farm implements used in the county has increased from $11,982 in 1879 to $105,764 in 1909.

The county seems to be in a transitional stage of development. The lumber and turpentine are nearing exhaustion, and signs of a new agriculture are in evidence in the clearing of land and the use of improved implements.

The greatest opportunity for agricultural improvement in the county is along the line of drainage. Almost all sections of the county are capable of either ditching or tiling and could, with comparatively little cost, be converted into land suitable for intensive agriculture. A general system of drainage is being inaugurated in the county, and should mark the beginning of a larger development along agricultural lines.

SOILS.

Bradford County lies wholly within the Coastal Plain, and its soils, with the exception of those which occupy the flood plain of streams or occur around some of the lakes and the Peat and Muck beds, are derived from old marine sediments. Since the elevation of the region above sea level, weathering has effected some changes in the deposits, and erosion has in places altered the original surface configuration.

The numerous sink holes in the southwestern part of the county are attributed to the solution and caving in of the underlying Vicksburg limestone. Although this limestone occurs beneath the whole county, it is too deep to have contributed any material to the formation of the soils, and is important only as it has influenced the topography and altered the drainage conditions.

Covering the limestone are unconsolidated deposits of varying thickness. A very close relationship exists between the nature of these underlying beds and the soils derived from them. Where the parent formation is a deep sand bed, naturally the resulting soil is a sand, and where the particles in the original formation are fine the soil derived from it is correspondingly fine in texture. The more clayey beds give rise to the sandy loams and fine sandy loams, the texture depending on the predominance of one or the other grade of included sand.

The soils of the county fall into three broad groups, according to their origin and mode of formation. They are sedimentary—and this group comprises the greater part of the area—alluvial, and cumulose. Each of these broad groups is subdivided into series and types. The series include soils of similar derivation, color, drainage, topography, and character of subsoil.

The type differentiation within any series is based entirely upon the texture or relative proportion of soil particles of the different grades or sizes. There are 5 series and 10 types of soils in the sedimentary group, 1 series of 2 types in the alluvial group, and 2 types in the cumulose group. The Norfolk, Leon, Scranton, Coxville, and Portsmouth series are in the first group and the Johnston in the second.

The soils of the Norfolk series cover 19 per cent of the area of the county. These soils are not widely distributed, being confined to those parts of the county having the strongest relief and best drainage, where oxidation has been able to extend into the subsoil. The larger bodies occupy the rolling country adjoining the larger streams or lakes. The soils are also found in small, elevated areas within the low-lying flatwoods section.

The Leon series is similar to the Norfolk in derivation, differing mainly in the presence of a hardpan stratum within the 3-foot profile. A relatively small area of one type is found in the county. It occupies the slightly elevated divides between streams in the flatwoods country. This soil is apparently about as well drained as the Norfolk soils.

The soil of the Scranton series is intermediate between the well-drained Norfolk soils and the poorly drained Portsmouth soils. It is represented by the fine sandy loam type, which is not extensively developed.

The soil of the Coxville series is represented by one type confined almost wholly to the north-central part of the county and occupying the long; slightly elevated ridge on the west side of New River, where it enters the county. Smaller, isolated areas occur in other sections of the county, always at a slightly higher elevation than the surrounding country. Insufficient drainage seems to have prevented complete oxidation of the subsoil material, as indicated by the mottled yellow, gray, and red color.

The Portsmouth series occupies the poorest drained part of the upland, comprising the low, flat country known as the "flatwoods." The soils are more widely distributed than those of any other series, and their total area is 59.6 per cent of the area of the county.

A conspicuous feature of the Portsmouth fine sand, Leon fine sand, and Portsmouth sand is the reddish-brown or dark-brown, somewhat compact layer of material, commonly called "hardpan," encountered at depths varying from a few inches to about 24 inches beneath the surface. This layer usually averages about 6 inches in thickness, although the underlying material is often discolored from leaching to a considerable depth. The position in the soil section that the hardpan layer occupies is at or near the place where the ground water stands the greater part of the year. The manner of formation of the layer is not definitely known, though the fact that it contains a large amount of organic matter would seem to indicate that organic compounds and some iron salts have been carried down in solution and precipitated at the place where the ground water usually stands or that fine particles of organic matter were carried down and fixed by filtration or some other process near the average level of the water table. In laboratory examination the material burns to a white fine sand, the small lumps quickly falling apart as the organic matter is burned out.

In the alluvial group in Bradford County are found two types of the Johnston series, which form 4.4 per cent of the area of the county. The types are found in all parts of the county.

Muck and Peat occupy considerable areas in the county, there being 41 square miles of the former and 22.1 square miles of the latter. The peculiarities of these types, as well as of the other series and types, will be discussed in detail in following pages. The names and extent of the several soils are shown in the following table, and their distribution is brought out by means of colors on the accompanying map.

Areas of different soils.

Soil	Acres	Per ct.	Soil	Acres	Per ct.
Portsmouth fine sand	135,680	39.3	Johnston fine sandy loam	9,472	2.7
Portsmouth fine sandy loam	48,448	14.0	Norfolk sand	6,848	2.0
Norfolk fine sand	35,136	10.2	Johnston fine sand	5,824	1.7
Muck	26,240	7.6	Scranton fine sandy loam	4,544	1.3
Portsmouth sand	21,760	6.3	Coxville fine sandy loam	2,112	.6
Peat	14,144	4.1			
Norfolk fine sandy loam	12,992	3.8			
Leon fine sand	11,776	3.4	Total	344,960	
Norfolk loamy sand	9,984	3.0			

GRAY SOILS.

SEDIMENTARY MATERIAL—SANDS AND CLAYS.

NORFOLK SERIES.

The Norfolk soils are characterized by the light-gray to grayish-yellow color of the surface soils, and by the yellow color and friable structure of the sand or sandy clay subsoils. They occupy nearly level to rolling uplands throughout the Coastal Plain and have been derived from marine sediments. The lighter members of this series are used for the production of early, medium, and late truck crops, and the heavier members for growing cotton, corn, and other general farm crops. In Florida certain of the types are used in growing citrus fruits. The sandy members predominate.

NORFOLK SAND.

The Norfolk sand consists of a gray or slightly brownish gray loose sand, underlain at about 5 to 8 inches by a gray, grayish-yellow or pale-yellow incoherent sand extending to a depth of 3 feet or more. In the lower part of the 3-foot section the material usually has a lighter color than the upper subsoil, especially in the lower lying, poorer drained situations.

In the lower situations, where the Norfolk sand grades into the Portsmouth soils, the surface soil is darker in color, usually a dark gray to grayish brown. The texture of the Norfolk sand varies somewhat. In places quartz fragments of the size of buckshot are encountered. In other places the type contains large quantities of fine sand.

The type occurs on slight elevations within bodies of Portsmouth soils. The largest areas are in the southern part of the county between the Santa Fe and New Rivers, and on the higher elevations above the Santa Fe River near Worthington. One area is developed in the northeastern part of the county near Highland, on the elevation which forms the divide between the Gulf of Mexico and the Atlantic Ocean.

The Norfolk sand was originally forested with longleaf pine, live oak, water oak, blackjack oak, and turkey oak. It supports a scant growth of wire grass.

Very little of the type is under cultivation. It is so thoroughly drained that crops are likely to suffer from drought even during ordinary periods of dry weather. The nature of the soil is such that with continuous cultivation the supply of organic matter becomes depleted unless special care is taken to maintain the supply by plowing under green crops frequently. The incorporation of humus in the soil increases its water-holding capacity and renders it less susceptible to drought. As a whole the type is easily handled. It can usually be plowed within a few hours after a heavy rain. It is adapted to early truck crops, but is used locally for the general farm crops.

NORFOLK FINE SAND.

The Norfolk fine sand consists of a gray or pale yellowish gray to dark-gray, rather loose, incoherent fine sand, underlain at about 5 to 8 inches by a yellow, pale-yellow, or grayish-yellow fine sand, extending to a depth of more than 3 feet. Like the surface soil, the subsoil is decidedly incoherent and the texture is often modified by the presence of larger particles, which occasionally attain the size of buckshot or small peas.

Variations from the typical soil are encountered where the type grades into other soils. Where the Norfolk fine sand passes into the Portsmouth fine sand the surface soil becomes darker in color because of the larger humus content, and the subsoil in its upper part is a dingy or dull yellowish-gray, appearing as though the hardpan layer found in the Leon soils at one time might have been present. The lower subsoil in such situations is grayish yellow or pale yellow.

Where the Norfolk fine sand grades into the Leon fine sand the surface soil of the former is grayish white, the subsoil having the dingy yellowish-gray color shown where it approaches the Portsmouth fine sand. In other areas the subsoil may incline more toward a whitish gray than is typical.

The surface soil of the Norfolk fine sand differs from that of the Portsmouth fine sand in that its organic-matter content is decidedly smaller, which causes the color to be lighter. The subsoil of the Norfolk fine sand is yellow, while that of the Portsmouth fine sand is white and usually includes a hardpan layer. The Norfolk fine sand occupies higher situations and is well drained. The chief difference between the Norfolk fine sand and the Leon fine sand is the white or very light color and the occurrence of a hardpan layer in the subsoil of the latter.

In extent the Norfolk fine sand is exceeded in Bradford County only by the Portsmouth fine sand and fine sandy loam. It occurs in almost all parts of the county, though its most general development is along the Clay County line southeast of Hampton, in the limestone sink region in the southwest corner of the county, and along the valley of Olustee Creek in the western part.

The topography of the Norfolk fine sand usually varies from almost level to undulating. The more nearly level areas are usually darker at the surface, owing to the accumulation of organic matter. In all cases the drainage is adequate and in the more rolling areas it is even excessive. In the southwestern part of the county the topography is slightly modified and the drainage made more thorough by the occurrence of numerous limestone sinks, through which the drainage water is carried off into subterranean channels.

The Norfolk fine sand supports a growth of pine, blackjack oak, turkey oak, water oak, and live oak. There is a scattered growth of wire grass.

An analysis of a typical sample of this soil to determine its lime requirements gave the following results:

	CaO per acre-foot	$CaCO_3$ per acre-foot
	Pounds	Pounds
Soil	2,450	5,900
Subsoil	1,750	3,500

Probably 80 per cent of the type is under cultivation. The soil is easily handled, and produces well under ordinary conditions. With continuous cultivation the humus content decreases rapidly unless maintained by the addition of green manure or barnyard refuse at frequent intervals. Crop rotation has received but little attention on the type, the farmers in most cases hoping to compensate by heavy applications of commercial fertilizers the damage done by injudicious farm practices. The restoration of this type from an impoverished condition may be more quickly accomplished than in case of most of the soils of the county.

The Norfolk fine sand is naturally a warm soil, while the texture is such as to retain, especially in the flat areas, a water supply sufficient for the maturing of most crops. It is regarded as a very desirable soil for early truck crops and is extensively utilized along the Atlantic seaboard for the growing of such crops as must be forced to an early maturity in order to command the high prices of the winter and early spring markets. Among the products of this class are Irish potatoes, cucumbers, peppers, snap beans, watermelons, cantaloupes, lettuce, radishes, green peas, and most of the berries. In certain localities cigar-wrapper tobacco has been successfully grown on this type under shades and with irrigation.

The type in Bradford County is used mainly for the general farm crops. Cotton and corn are grown extensively and do well with heavy applications of commercial fertilizer. Corn averages about 15 bushels and cotton about one-third bale per acre. Cowpeas and velvet beans do well and are excellent crops to include in rotations. Sugar cane ordinarily produces 8 to 15 barrels of sirup per acre, though the yield varies widely with the season. Sweet potatoes produce about 300 bushels per acre. Oranges and grapefruit do exceptionally well on this type. There are several small commercial groves in the southeastern part of the county, and small groves for home use are numerous. Peaches are also grown in the same locality.

The price of land of this type of soil in sections more remote from markets or shipping points is $10, and in more favorable locations from $20 to $40 an acre.

NORFOLK LOAMY SAND.

The Norfolk loamy sand consists of about 8 inches of brownish-gray or light-brown loamy sand, resting upon a brownish-yellow loamy sand. The color becomes lighter with depth, and at 36 inches the material is usually bright yellow or golden yellow. Both the soil and subsoil are decidedly more coherent than the material of either the Norfolk fine sand or Norfolk sand, and the type is considerably more retentive of moisture. In the southwestern part of the county some small areas of loamy fine sand are included with this type. The agricultural value of such areas is similar to that of the main type, which fact, with their small extent, made it seem inexpedient to show them as a separate type on the map.

The Norfolk loamy sand occupies nearly level situations, slightly elevated above the adjacent Portsmouth soils, into which it grades almost imperceptibly. In places erosion has given a gently undulating topography. In lower positions near the poorer drained Portsmouth soils the color of the soil grades from the typical to a dark gray or dark grayish brown, and of the subsoil to a yellowish brown. Where the topography is undulating the color of the soil and subsoil varies, the lighter shades of brown prevailing on the slopes and the darker colors in the depressions and flat areas.

Owing to its position and surface configuration the type is thoroughly but not excessively drained, and under ordinary conditions it retains sufficient moisture for the maturing of almost any of the crops commonly grown.

In its natural condition the type supports a growth of longleaf pine, a few scattered water oaks, and a thrifty growth of wire grass.

The type is confined to the south-central and southwestern parts of the county, and comprises a part of the better drained country above the New and Santa Fe Rivers and Olustee Creek.

Most of the Norfolk loamy sand is under cultivation. It is one of the most productive soils in the county, and is used for the production of the general farm crops common to the region. Fertilizers are used extensively and are deemed necessary for the best yields. From 10 to 30 bushels of corn and from one-third to one-half bale of cotton per acre are the ordinary ranges in the yields of these staples. Velvet beans, cowpeas, peanuts, and oats do well. Litmus tests show the soil to be decidedly acid. Applications of either burnt lime or limestone would be beneficial.

Land of this type ranges in value from $15 to $25 an acre, the higher price being asked for improved property of even surface and near markets or shipping points.

The following table gives the results of mechanical analyses of samples of the soil and subsoil of this type:

Mechanical analyses of Norfolk loamy sand.

Number	Description	Fine gravel	Coarse sand	Medium sand	Fine sand	Very fine sand	Silt	Clay
		Per ct.	Per ct.	Per ct.	Per ct.	Per ct.	Per ct.	Per ct.
261115	Soil	1.1	14.1	21.9	36.4	12.0	5.5	8.9
261116	Subsoil	.5	12.0	24.9	38.9	10.4	3.8	9.7

NORFOLK FINE SANDY LOAM

The surface soil of the Norfolk fine sandy loam is a light-gray to light brownish gray fine sand, underlain at about 6 to 10 inches by a yellow or pale-yellow loamy fine sand to fine sandy loam, which becomes heavier with depth, and at an average depth of about 28 inches passes abruptly into a yellow or pale-yellow, friable fine sandy clay. The surface soil is darker in the more nearly level areas, where the organic-matter content is higher, and the lower part of the subsoil in the poorer drained depressions is often slightly mottled with yellowish red and sometimes with gray.

Although this type is not extensive, it occurs in all parts of the county. The largest single area lies southwest of Lake Butler. As a whole this type is well drained, although there are slight depressions in some areas which receive the surface drainage from the adjoining higher land and sometimes remain wet for long periods. The surface features of the Norfolk fine sandy loam resemble very closely those of the more nearly level areas of the Norfolk fine sand. The topography is nearly level to undulating. This type is much more retentive of moisture than the Norfolk fine sand.

The natural vegetation consists mainly of a heavy growth of longleaf pine, with scattered water oak, blackjack oak, and live oak on the more sandy phases. Wire grass grows luxuriantly.

The soil is naturally well supplied with humus, which accounts for the dark color of the immediate surface of forested areas. By continuous cultivation the content of vegetable matter is diminished, and the soil loses its dark color and loamy feel unless additional vegetable matter is supplied. There is a general need over this type for the practice of systematic crop rotation and for the application of large quantities of stable manure or the plowing under of occasional green crops, such as cowpeas, velvet beans, or beggarweed, in order to maintain the supply of humus in the soil.

Most of the type is under cultivation. It is considered one of the strongest soils in the county for general farm crops. Corn and cotton do well without heavy applications of commercial fertilizer. Corn averages about 18 bushels per acre, though some farmers secure much larger yields. Cotton ordinarily produces from one-fifth to one-third bale per acre. Cowpeas and velvet beans do well. Peanuts are frequently planted in the corn rows and fed to stock after the corn has been harvested. Oats and rye are grown for forage and are cut just before the grain ripens. The soil is well adapted to millet, which has lately been introduced. Sweet potatoes and Irish potatoes both produce good yields. Sugar cane, strawberries, pecans, Scuppernong grapes, and bramble fruits also succeed on the type.

Though the Norfolk fine sandy loam is not quite so early in maturing vegetables as the Norfolk fine sand, it is used extensively in other localities for trucking with good results. Cigar-wrapper tobacco has been grown successfully under shade on this type in other sections of Florida.

The Norfolk fine sandy loam is held at about the same prices as the Norfolk fine sand.

LEON SERIES.

The Leon series comprises the loose, light-gray to white sandy soils of the south Atlantic and east Gulf coast flatwoods region, which in their typical development have a hardpan stratum usually at a depth of 12 to 24 inches. This stratum ranges from 8 to 10 inches in thickness and consists of a compact layer of fine sand or sand ranging in color from black to dark rusty brown in the upper 2 or 3 inches to rusty brown or slightly darker in the lower portion. The material of this layer runs high in organic matter and low in iron, and although the color would suggest cementation with iron, the analyses indicate that the compactness is due rather to the presence of organic matter. In places the stratum lies sufficiently near the surface to be plowed up, under which condition it is said crops give poor yields. But one type of the series, the fine sand, occurs in Bradford County.

LEON FINE SAND.

The Leon fine sand consists of about 3 inches of gray or dark-gray fine sand underlain by a white or light gray, incoherent fine sand, which extends to a depth of 3 feet or more. At depths varying from 8 to 30 inches, though usually at 18 to 24 inches, a black or dark-brown, dense hardpan layer is encountered, which is penetrated with difficulty by the soil auger. This hardpan is similar to that occurring in both the Portsmouth fine sand and Portsmouth sand, but the material is usually more dense. In exceptional cases the hardpan layer does not occur in the 3-foot section, though its absence is less frequent than in the case of the other two types in which a hardpan occurs.

This type differs from the Portsmouth fine sand in the light color of the soil and the general incoherent nature of the surface soil, due to its low organic matter content. It differs from the Norfolk fine sand in the lighter color of the soil and subsoil and the presence of the hardpan layer.

The Leon fine sand occupies a slightly higher position than the Portsmouth fine sand. It occurs on sandy ridges which form the divides of streams in the flatwoods country. Its elevation above the surrounding country is slight and the slope in most cases almost imperceptible. The type supports a characteristic native vegetation of scrubby saw palmetto, long-leaf pine, wire grass, gallberry, and a variety of evergreen oak that attains a height usually not exceeding 8 inches. The trees are commonly called "oak runners" on account of their long roots, which spread out just beneath the surface.

The Leon fine sand has its most extensive development to the north and northwest of Lake Butler. Practically none of the type is under cultivation, and it is generally considered an unproductive soil. Owing to the heavy growth of saw palmetto and oak runners, the land is difficult to clear. The loose, open structure of the soil and the small quantity of organic matter present tend to make the drainage excessive, and even under ordinary conditions crops suffer for lack of moisture. With irrigation and liberal applications of commercial fertilizers a great variety of vegetables common to the region can be grown, though only by very intensive methods can success be attained in the cultivation of the type.

COXVILLE SERIES.

The Coxville series comprises dark-gray to nearly black soils. The subsoils range from a moderately mellow, friable clay in the upper portion to yellowish, rather plastic, compact clay mottled with drab and light red in the lower portion. The topography is prevailingly flat, with frequent sparsely forested areas. The treeless lands are found in the savannas of the seaward portion of the Atlantic Coastal Plain. The flat surface induces poor drainage. The soils are used for the production of cotton, corn, and oats. In the Carolinas strawberries are grown with profit. When well drained the types are somewhat more productive than the Norfolk soils. The series has been mapped mainly in North Carolina, South Carolina, and Georgia. Only one type in the series is found in Bradford County, and the area of this type is but little more than 3 square miles.

COXVILLE FINE SANDY LOAM.

The surface soil of the Coxville fine sandy loam consists of gray to dark-gray or nearly black fine sand containing a high percentage of organic matter. At an average depth of about 8 inches the material passes abruptly into a very pale yellow fine sand, which in the less thoroughly drained areas is almost white or light gray. At about 18 inches a more distinctly yellow loamy fine sand, which is unevenly mottled with drab and gray, is encountered. With increasing depth the mottlings become more pronounced and the texture heavier, until at about 28 inches a friable fine sandy clay or heavy fine sandy loam, having a complexly mottled yellow, drab, red, and brown color, is encountered. In the lower part of the 3-foot section the subsoil is decidedly heavy and in places is a plastic clay.

The Coxville fine sandy loam in Bradford County is not typically developed. It was only separated from the Portsmouth fine sandy loam because of its slightly better drainage and its mottled subsoil. The color of the surface soil departs from the typical gray in places, becoming brown or grayish brown. The type also varies considerably in color with depth, though throughout the 3-foot section the soil has a mottled color. The texture of the deep subsoil is variable also, ranging from a heavy fine sandy loam through a fine sandy clay to a stiff clay containing a little fine sand. In the largest area of this type, east of Sapp and west of the point at which New River enters the county, the lighter subsoil predominates, while in the area along the Raiford and Lawtey road the material is heavier at lower depths.

The type occupies slightly elevated areas within the Portsmouth soils. Its drainage and oxidation represent an intermediate condition between the lower lying Portsmouth soils and the more elevated and better drained soils of the Norfolk series. The surface is flat to very slightly undulating. The type includes slight depressions occupied by cypress ponds and "bays."

The Coxville fine sandy loam supports a natural growth of long-leaf yellow pine, slash pine, and wiregrass. Small, stunted saw palmettos are occasionally seen, though they do not grow as profusely on this type as on some of the other soils. Most of the land has been cut over and the merchantable timber removed. The remaining trees are "boxed" for turpentine. Practically none of the type is under cultivation, though it is a better soil for general farm crops than the Portsmouth fine sand, and the yields should be equal to if not better than those secured on the Portsmouth fine sandy loam. With small expenditure the Coxville fine sandy loam could be drained by means of open ditches. Land of this type is valued at $8 to $10 an acre.

BLACK SOILS.

SEDIMENTARY MATERIAL—SANDS AND CLAYS.

Portsmouth Series.

The Portsmouth series includes dark-gray to black soils, resting on light-gray or mottled gray and yellow subsoils. The soils are high in organic matter, and the heavier members are always plastic, though carrying a noticeable quantity of sand. The soils of this series are developed in flat or slightly depressed, poorly drained areas. The series is most extensively developed in the flatwoods or low seaward portion of the Coastal Plain east of the Mississippi River, though scattered areas are found also in the higher parts of the Coastal Plain country. When drained the different types are used to grow corn and truck crops. In extent, at least, this series is the most important in Bradford County.

PORTSMOUTH SAND.

The Portsmouth sand consists of a dark-gray to black sand, 5 to 10 inches deep, underlain by a dark-gray to gray sand. Somewhere within the 3-foot section a hardpan layer is generally encountered, usually between 18 and 24 inches. This stratum averages about 6 inches in thickness and is dark colored, while the material beneath it is stained a dark brown by leachings from above.

In places the hardpan stratum is not encountered within the 3-foot section. Like that occurring in the Portsmouth fine sand and the Leon fine sand, the hardpan layer is denser in its upper 3 inches, where it has a characteristic dark-brown or black color. Beneath this dense portion the sand particles are less closely cemented together and the material is lighter in color. In places the lower subsoil becomes lighter in color with depth, and at 3 feet is light gray or faintly brownish gray.

The lower depth of the 3-foot section is usually saturated, and the water table in many cases rises to within 18 inches of the surface. The type owes its characteristic dark color to an accumulation of organic matter in the soil under imperfect drainage conditions.

As compared with other members of the series the Portsmouth sand has a small area in the county. In the eastern section, near the Clay County line, the type occurs on the gentle slope from the general level of the flatwoods to the higher country occupied by the Norfolk sand. Between Brooker and Worthington the soil is found typically developed. It has a flat to very gently undulating topography, and is classed as a "flatwoods" soil. "Bays" and cypress ponds of varying size are commonly encountered within it. The native vegetation comprises longleaf pine, slash pine, saw palmetto, gallberry, and wire grass.

Very little of the type is under cultivation. Where well drained, good yields of certain truck crops, especially cabbage and onions, may be expected. This soil does not warm up in the early spring, as do the lighter soils of the Norfolk series, but the larger yields compensate for the later maturity of the crops. Of the general farm crops, the type is best adapted to corn. The soil, however, is too light for general farming. Applications of lime are generally beneficial on all of the Portsmouth soils.

PORTSMOUTH FINE SAND.

The Portsmouth fine sand, in its typical development, consists of a dark-gray to black fine sand, which has a decided loamy feel, owing to its high organic-matter content. The black surface material passes abruptly into a light-gray, incoherent fine sand at depths varying from 5 to 15 inches and averaging about 8 inches. This is underlain by a dense, compact hardpan layer, usually at a depth of 18 to 24 inches. The hardpan stratum is characteristically dark brown or black in the upper part, but it quickly grades into a copper-brown, rusty-brown, or "coffee-grounds" color, and becomes less compact with depth. This layer is usually from 4 to 8 inches in thickness, and the dark, dense portion comprising the upper part averages 3 inches. Below the hardpan stratum the material to a depth of 36 inches or more varies from a light-brown to a light-gray, incoherent fine sand, usually saturated.

The depth to the hardpan layer is extremely variable. It may occur immediately below the black surface soil or at any depth within the 3-foot section, and in places it is entirely absent. In the latter case the soil grades from the black surface material into a gray fine sand, which continues with uniformity of color and texture to a depth of 3 feet or more. Though all these variations may occur within a comparatively small area, it is quite exceptional to find the hardpan absent over a tract of any considerable extent. The areas having no hardpan in the 3-foot section comprise a phase intermediate between the typical Portsmouth fine sand and the Portsmouth fine sandy loam.

The origin of the hardpan layer in the subsoil is not definitely known, though it is believed to be caused either by filtration or precipitation of organic matter, carried downward as fine particles or in solution by the percolating water, at or near the mean level of the water table. The hardpan stratum has frequently been ascribed to the precipitation of iron salts leached from the surface, and it is a popular belief that it is rich in iron, but laboratory tests show that the content of iron is not very much greater than in other parts of the soil section, while the content of organic matter is high. Water solutions show a brownish color similar to that of the streams of the region, which indicates that a part of the cementing material is soluble.

The Portsmouth fine sand is of greater extent and more widely distributed than any other type, areas of this soil occurring in all parts of the county. It has a nearly level topography, slightly varied by low ridges and gentle slopes toward depressed areas or cypress ponds. The type occupies the larger part of the "flatwoods" section and is locally designated as "sand-soak land," "hardpan land," and "palmetto flatwoods." Saw palmetto is usually abundant, except in the northeastern part of the county. The type supports a thick growth of gallberry and usually of wire grass. The tree growth consists of longleaf pine, shortleaf pine, and slash pine. Most of the longleaf pine is "boxed" for turpentine, and large tracts of "cut-over" land are included in the type. A very small part of the type is under cultivation.

The most important factor limiting crop production on the Portsmouth fine sand is drainage. The greater part of the type is sufficiently elevated above the stream channels to permit drainage by means of open ditches, and much of the type can be cheaply drained by individuals. It is believed that thorough drainage will gradually eliminate the detrimental effects of the hardpan. Laboratory tests show that a part of the hardpan material is soluble, and field observations show a discoloration of the white sand underlying the stratum by leachings. With thorough underdrainage it is believed that this part of the material would be carried away and that the stratum would then disintegrate, or at least become more permeable.

In connection with drainage, the application of lime will be found beneficial. Field tests show the soil to be acid throughout the 3-foot section, and the hardpan stratum to be exceptionally so. Laboratory tests of a typical sample show the following quantities of lime necessary to neutralize the acidity:

Lime requirements of Portsmouth fine sand.

	CaO per acre-foot	$CaCO_3$ per acre-foot
	Pounds	Pounds
Surface soil	3,850	7,700
Hardpan stratum	6,300	12,600
Subsoil	2,450	5,900

Many farmers deem it unwise to bring the material of the brown hardpan layer to the surface in plowing, as it is said crops give poor results where this material is exposed. In some cases dynamite is used to break up the hardpan layer and improve its condition for plant growth.

The supply of organic matter which gives to the Portsmouth fine sand its characteristic dark color and loamy texture is rapidly depleted by cultivation unless frequent additions are made, the soil becoming ashy gray in color. Plowing under crops of cowpeas, velvet beans, or beggarweed is the best means of maintaining the organic-matter content where stable manure is not available.

The strawberry industry has attained its highest development on the Portsmouth fine sand around Starke and Lawtey. The berries grown upon this type usually reach the market a little earlier than those grown on the heavier soils.

Although the type is better adapted to early truck crops, small areas in more remote sections of the county are devoted to staple crops. Corn yields average about 15 bushels per acre, seed cotton produces one-fifth to one-third bale per acre, and oats about 10 bushels. Cabbage and tomatoes do well on the type. Sweet potatoes average about 250 bushels.

The price for which the Portsmouth fine sand is sold varies greatly with its proximity to market. In more remote sections it can be bought for $5 an acre, while that near market or shipping points, and suitable for strawberry culture, but unimproved, is valued at about $10. The most desirable areas, cleared, improved, and close to market, are held at about $80 an acre.

PORTSMOUTH FINE SANDY LOAM.

The soil of the Portsmouth fine sandy loam consists of a black or very dark gray fine sand having a high organic-matter content. At an average depth of 8 to 10 inches this material is underlain by a gray to nearly white fine sand, which continues to a depth generally varying from 18 to 34 inches, where it passes abruptly into a drab, mottled drab and yellow, or mottled gray and yellow fine sandy loam to slightly plastic fine sandy clay. A hardpan layer, similar to that encountered in the Portsmouth fine sand, is sometimes encountered in the sandy layer lying between the surface soil and the heavier subsoil, but the occurrence of hardpan in this type is rather exceptional, and where it does occur it is seldom as thick or dense as that found in the fine sand type. Wherever the fine sandy loam or mottled clay is encountered within the 3-foot soil section, areas otherwise resembling the Portsmouth fine sand were mapped as the fine sandy loam.

Areas of this type are scattered throughout the county, the largest lying around Raiford and extending east to the county line. Another large area lies south of Starke. The type occupies poorly drained, flat, or depressed areas, usually without sufficient slope or drainage outlet for the establishment of good drainage. Irregular-shaped "bays" and "cypress ponds" are common throughout the type. A part of the type occupies long, gentle slopes where the fall is sufficient to make artificial drainage, by means of extensive systems of ditching, practicable.

Unless artificially drained much of the type is too wet for farming, and consequently a large part of it is unimproved. The forest growth consists largely of pine. Most of the marketable timber has been or is being removed, while practically all of the remainder is "boxed" for turpentine. The gallberry and wire grass grow profusely.

When properly drained the Portsmouth fine sandy loam is capable of producing good yields of either the staple crops or such special crops as strawberries, Irish potatoes, lettuce, tomatoes, eggplant, cauliflower, and celery. Between Lawtey and Raiford the type is used extensively for strawberries. The plants are set in beds, which are thrown up a foot or more above the general level of the field in order to protect the roots from excessive moisture. While the berries do well with proper fertilization and cultivation, they are slightly later than those grown upon the warmer and better drained soils. This is true in the case of practically all crops grown.

This soil is also used successfully in the production of Irish potatoes and tomatoes. Corn averages about 15 bushels and cotton about one-fifth bale per acre. The chief deficiency of the type is lack of drainage, and where ditching is not practical the bed or ridge method of cultivation is necessary. In places the beds are laid off so as to accommodate four to six or more rows of corn or cotton.

This type is a stronger soil than the Portsmouth fine sand, and equally good results are obtained with lighter applications of commercial fertilizers. The Portsmouth fine sandy loam is also easier to improve and is more resistant to drought than the Portsmouth fine sand. The type in its natural condition is slightly acid and, like many other poorly drained black soils, needs lime.

Prices for land of this type range from $8 to $15 an acre, according to location.

Scranton Series.

The Scranton soils are characterized by their dark-gray to black surface soils and friable yellow subsoils. The former have the characteristics of the Portsmouth series; the latter resemble the subsoils of the Norfolk. In the poorer drained areas grayish mottling is frequently noticeable in the deeper subsoil. The surface is flat and the land is generally in need of drainage, such as can be secured in most cases by constructing ditches. The Scranton soils are most extensively and typically developed in the flatwoods country near the coast of the South Atlantic States and in the low flatlands near the Gulf of Mexico, east of the Mississippi River.

SCRANTON FINE SANDY LOAM.

The surface soil of the Scranton fine sandy loam, to an average depth of 6 inches, consists of a black or dark-gray fine sand, which, on account of its high organic-matter content, has a decidedly loamy feel. This material passes abruptly into a pale-yellow or grayish-yellow fine sand, which is uniform in texture and color to a depth averaging about 28 inches, where a yellow or slightly mottled yellow and gray fine sandy loam or friable fine sandy clay is encountered. In places the fine sandy loam or fine sandy clay does not occur within the 3-foot section, in which case the soil would have been mapped as the fine sand of the series but for the patchy occurrence of such bodies.

The type is intermediate between the poorly drained Portsmouth soils and the higher and better drained Norfolk soils. The surface soil is essentially similar to those of the Portsmouth types, while the subsoil resembles very closely that of the poorer drained areas of the Norfolk fine sandy loam.

The Scranton fine sandy loam occupies positions intermediate between the low-lying, flat Portsmouth fine sand and the more elevated Norfolk soils. The surface is flat, and only a few feet higher than the adjoining flatwoods country. The drainage, while decidedly better than that of the Portsmouth soils, is in many cases insufficient for the best results with crops.

After a few years of continuous cultivation the organic-matter content of the surface soil becomes depleted and the material assumes a much lighter color, in which case the type becomes more like the Norfolk. As in the case of most soils of deficient drainage, the Scranton fine sandy loam shows an acid reaction when tested with litmus. Applications of lime, either in the form of burnt lime or ground limestone, are therefore necessary to enable the farmer to secure the maximum yields of most crops.

As in the case of the Portsmouth soils, the most important factor influencing crop production on the Scranton fine sandy loam is drainage. Open ditches have been constructed in places to carry off the excess water. Crops are sometimes grown on beds raised a few feet above the general surface and corn and cotton are grown on high ridges.

The type is inextensive, but is encountered in nearly every part of the county. In its natural condition it supports a growth of pine, gallberry, and wire grass. A large part of the type is under cultivation to the general farm crops. Strawberries and vegetables are also grown. Strawberries do particularly well on this soil. With proper fertilization, oats, corn, sugar cane, forage crops, Irish potatoes, tomatoes, and a large number of vegetables can be grown successfully.

ALLUVIAL MATERIAL—MIXED DERIVATION.

Johnston Series.

Soils of the Johnston series are distinguished by the black color of the surface and the gray, yellow, and brownish color of the subsoils. These soils are alluvial first-bottom soils in the Coastal Plain region. They are subject to overflow. They are derived from materials washed for the most part from Coastal Plain soils, with an admixture of material from Piedmont soils along streams issuing from that province into the Coastal Plain province. No such admixture is found in the soils of the present survey.

JOHNSTON FINE SAND.

The soil of the Johnston fine sand, to a depth varying from 6 to 15 inches and averaging about 8 inches, consists of a black or dark-gray fine sand with a high organic-matter content. The subsoil is a light-gray or gray fine sand. Its texture is decidedly variable, and at different depths in the same section the size of the particles often varies from fine to coarse, though the fine sand usually predominates. In places the heavy clay subsoil of the Johnston fine sandy loam is encountered within the 3-foot section, while at a short distance in any direction the fine sand continues to a depth of 3 feet or more. The two types grade into each other and are frequently so closely associated as to necessitate mapping according to the predominating type. In places the Johnston fine sand grades into the uplands so imperceptibly that it is difficult to determine the exact boundaries between the overflowed land and the upland, there being a close resemblance between this type and the higher lying Portsmouth fine sand. Where the Johnston fine sand grades into the Portsmouth fine sand, the typical Portsmouth hardpan is frequently present, even though the area is regularly overflowed. On the lower areas, near the stream banks, the black surface layer is sometimes only 2 to 4 inches deep and the soil often has a decidedly loamy feel on account of the greater silt content. These silty areas, however, are too small to be separated on the map from the typical.

This soil occupies the flood plains of the smaller streams of the county. Most of the type is elevated only a foot or two above the general level of the streams, and during seasons of heavy rainfall it is entirely inundated. The material consists of alluvial deposits derived from the upland soils of the drainage basins of the streams along which the type occurs. The topography is level, with only an imperceptible slope toward the stream channels. There are a few very slight ridges and swales. In the southwestern part of the county there are two narrow strips of soil similar to this type, which, although apparently of alluvial origin, stand above overflow somewhat like second-bottom soils. The relatively high position occupied by these areas has resulted from the formation of limestone sinks nearer the stream.

The Johnston fine sand supports a characteristic natural growth of shortleaf and longleaf pine, slash pine, magnolia pine, palmetto, scrub varieties of holly and oak, titi, gallberry, bay, ironwood, haw, water or turkey oak, sweet gum, ash, magnolia, hickory, myrtle, and pecan.

Practically none of the type is cleared for agricultural use. The merchantable timber has in most cases been removed, and the remaining longleaf pine is "boxed" for turpentine. The type is used largely for pasture. Water stands over much of this soil during a large part of the year, and artificial drainage is necessary before it can be utilized for farming.

The following table gives the results of mechanical analyses of samples of the soil and subsoil of this type:

Mechanical analyses of Johnston fine sand.

Number	Description	Fine gravel	Coarse sand	Medium sand	Fine sand	Very fine sand	Silt	Clay
		Per ct.	Per ct.	Per ct.	Per ct.	Per ct.	Per ct.	Per ct
261136	Soil	0.2	0.7	1.5	45.9	37.7	6.7	7.7
261137	Subsoil	.0	.6	1.8	54.1	35.0	5.3	3.3

JOHNSTON FINE SANDY LOAM.

The soil of the Johnston fine sandy loam, to an average depth of about 15 inches, consists of a black or very dark gray fine sand or loamy fine sand, containing a large amount of organic matter. Beneath this the material is a light-gray or gray fine sand, which, at about 24 inches, grades into a drab and yellow mottled, plastic fine sandy clay or clay. In places the black surface layer is not more than 3 or 4 inches deep. The light-gray subsurface soil, or the material between the black surface and the stiff clay subsoil, is sometimes mottled with yellow or brown, and occasional strata of orange-colored sand are encountered between these depths.

The Johnston fine sandy loam is the predominating bottom soil of the county, and is developed along the larger streams. The bottoms along the Santa Fe and New Rivers are prevailingly of this type, though in places in such areas the clay does not occur within the 3-foot section.

The type occupies the low first bottoms along the streams and is subject to frequent overflow. Adjoining the stream there are some low, poorly drained areas where the surface seldom dries between overflows. These areas constitute a swampy phase of the type, which supports a natural growth consisting mainly of water or turkey oak, ironwood, haw, sweet gum, ash, and slash pine. Owing to the accumulation and decomposition of vegetable matter under conditions of poor drainage, the surface soil has a somewhat mucky nature, which is not possessed by the better drained part of the type.

The Johnston fine sandy loam is composed of alluvial stream deposits, consisting wholly of reworked Coastal Plain material.

Practically none of the type is under cultivation. In most cases the merchantable timber has been removed and the remaining longleaf pine is "boxed" for turpentine. The type is devoted largely to pasture and the production of naval stores. It cannot be profitably utilized for agriculture until reclaimed by means of extensive drainage systems.

The results of mechanical analyses of samples of the soil and subsoil of this type are given in the following table:

Mechanical analyses of Johnston fine sandy loam.

Number	Description	Fine gravel	Coarse sand	Medium sand	Fine sand	Very fine sand	Silt	Clay
		Per ct.	Per ct.	Per ct.	Per ct.	Per ct.	Per ct.	Per ct.
261124	Soil	0.5	5.2	10.4	52.6	21.1	6.4	4.1
261125	Subsoil	.7	6.1	9.4	48.8	18.5	5.7	10.8

MISCELLANEOUS MATERIAL.

PEAT.

The soil mapped as Peat consists of brown, partially decomposed vegetable matter having a depth of 3 feet or more. The material to a depth of 3 or 4 inches is usually black or nearly black in color and has a fine texture, the vegetable matter having largely decomposed beyond the fibrous stage, though some of the plant remains show the original structure. The material is free from grit or mineral matter.

The topography of the Peat is level, and the surface, with the exception of frequent tussocks of vegetation that have grown up around roots, stumps, and cypress knees, is inundated during the greater part of the year. The material is sufficiently fibrous to absorb and retain large quantities of water. A larger part of the type, however, could be effectively drained. The Peat is deeper in some places than in others, and when it is drained uneven shrinkage might cause slight irregularities in the surface configuration. The type occurs in the larger cypress ponds, "bays," and in low areas around the edge of lakes.

While it is probable that the Peat is derived largely from the accumulation and subsequent decomposition of sphagnum moss in areas of poor drainage. the remains of other water-loving plants and trees are also included with the material. The deposits have accumulated within ponds or lakes or along the courses of sluggish streams.

Much of the type supports a dense growth of cypress, bay, smilax or "bamboo vine," pine and a variety of swamp huckleberry. There is also a growth of sphagnum moss and ferns.

While Peat when well drained is well adapted to the production of special crops—such as celery, onions, cabbage, tomatoes, and

Irish potatoes—it is less desirable for the general farm crops than Muck. A part of the Peat bed around Sampson Lake was at one time partially drained and used for several years for growing rice, but the crop suffered from "blight," so that rice production became unprofitable, and the cultivated area was allowed to return to its submerged condition.

MUCK.

The material mapped as Muck consists of partially decomposed vegetable matter mixed with a small amount of mineral matter, mainly fine sand. Decomposition has advanced to that stage where the original structure of the plant material has largely been obliterated. The surface soil is usually underlain at about 15 inches by a dark-gray fine sand. At about 24 inches the gray fine sand generally passes into a dark fine sandy loam to fine sandy clay.

This type occupies "bays" or "cypress ponds" scattered throughout the large areas of Portsmouth fine sand, Portsmouth fine sandy loam, and Coxville fine sandy loam. Portions of the larger swamps and all of the large swamps north of Santa Fe Lake are chiefly Muck. The surface is under water during the greater part of the year. Cypress, bay, and gum are the principal trees, while ferns and sphagnum moss grow close to the banks and where the water is not too deep. Frequently titi and myrtle fringe the depressions.

The Muck cannot be utilized for agricultural purposes without artificial drainage. The reclamation of the type can generally be effected by open ditches. When thoroughly drained Muck is one of the best soils in the county for the production of vegetables, especially celery, cabbage, tomatoes, Irish potatoes, and onions, which require a soil having a large humus content. It is also well adapted to sugar cane. After the type is thoroughly drained, the application of lime in sufficient quantities to correct acidity is beneficial. General farm crops—such as corn, cotton, and oats—do exceptionally well on drained Muck areas after sufficient applications of lime have been made.

There are many small areas of Muck, varying in size from 1 to 4 or 5 acres, occupying small depressions within the various types throughout the county. These are not shown on the map, owing to their small size.

SUMMARY.

Bradford County is situated in the northeastern part of Florida, and has an area of 539 square miles, or 344,960 acres. Starke is the county seat and largest town. The topography varies from flat to hilly, and much of the county is poorly drained. There is a range in elevation from 135 to 175 feet above sea level.

The climate is mild, the mean temperature for the coldest months, December, January, and February, being about 56° F., and the mean summer temperature 81° F. There is a mean annual precipitation of about 51 inches.

There are about 110 miles of railroad in the county. Two main lines of railroad connect the county with Jacksonville and a third with northern points. Two branch roads extend into the southern part of the county.

Only a small part of the county is under cultivation, although agriculture seems to be entering a period of development. The lumber and turpentine industries are important. Where the forest growth has been removed the lands are being cultivated, and there is a general tendency toward more intensive farming, such as the growing of strawberries or truck crops in place of cotton or corn.

The farm crops consist of corn, cotton, strawberries, cowpeas, velvet beans, peanuts, oats, rye, millet, sugar cane, sweet potatoes, Irish potatoes and rice. Of these corn occupies the largest total area, but strawberries bring the largest returns. Long-staple cotton is grown exclusively. Cowpeas, velvet beans, peanuts, oats, rye, and millet are grown mainly for forage. Sugar cane, sweet potatoes, Irish potatoes, and rice are minor crops grown largely for home consumption, though with several of these there is a possibility of commercial development. Oranges, grapefruit, and pecans are grown on a small scale for local markets. The greatest agricultural possibility of the county is along the line of truck farming.

The soils consist of sands, fine sands, and fine sandy loams and owe their origin to unconsolidated deposits of the Coastal Plain. The types are comparatively few and belong to the Norfolk, Portsmouth, Scranton, Leon, Coxville, and Johnston series, with the two miscellaneous types, Peat and Muck.

The Norfolk series includes the light-colored upland soils, which occupy the higher areas and are comparatively well drained. The fine sand and sand are good early truck soils. The fine sandy loam

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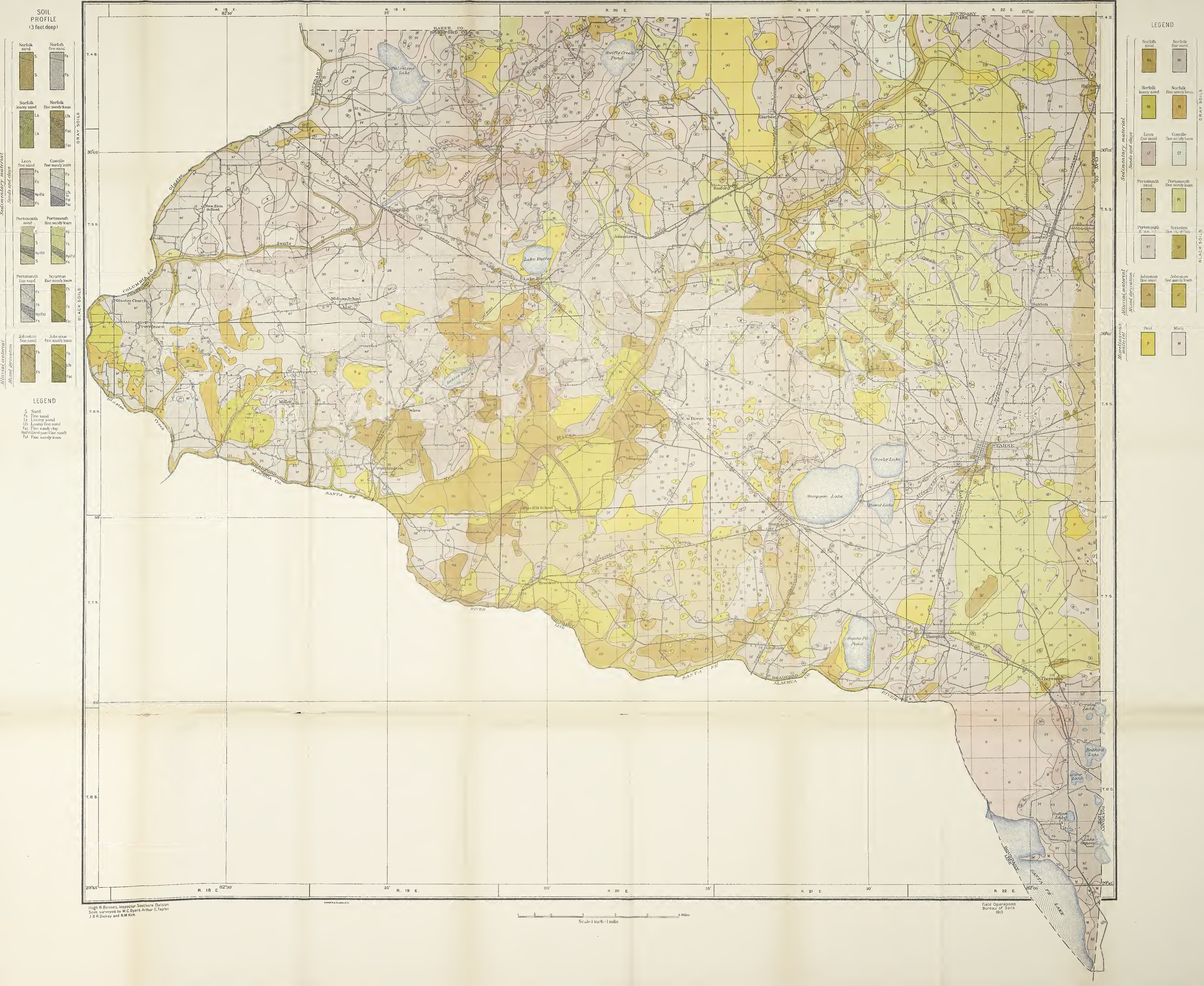
CURTIS F. MARBUT, IN CHARGE SOIL SURVEY

SOIL MAP
FLORIDA
BRADFORD COUNTY SHEET

FLORIDA STATE GEOLOGICAL SURVEY
E. H. SELLARDS, STATE GEOLOGIST



Hugh H. Bennett, Inspector Southern Division
Soils surveyed by W. C. Byers, Arthur E. Taylor,
J. B. R. Dickey and N. M. Kirk.

SNYDER & BLACK, N.Y.

Field Operations
Bureau of Soils
1913

is one of the best soils in the county for general farming. The loamy sand is also well adapted to the general farm crops.

The Portsmouth soils all need drainage to fit them for agriculture. The fine sand comprises the largest area and is the main type in the flatwoods country. The strawberry industry has been developed on this soil around Starke and Lawtey. It is a good truck soil. The fine sandy loam type is less well drained but is inherently more productive. Strawberries constitute the main crop, though corn and cotton are grown successfully on well-drained areas. The sand type is inextensive. It has about the same crop value as fine sand.

The Scranton fine sandy loam is a good soil for truck crops, but is usually deficient in drainage. The Leon series is represented by only one type, the fine sand. It is devoted almost exclusively to lumbering and turpentining. The Coxville fine sandy loam is also in need of drainage. When reclaimed it is well adapted to truck crops.

The alluvial soils are represented by two types of the Johnston series, the fine sand and fine sandy loam. These soils are subject to frequent overflow and are not under cultivation.

Peat and Muck are unfit for agriculture until drained.

The greatest general requirement of the soils in the county is drainage. After drainage, the application of lime to correct the acid condition of the soils is necessary.

The development of intensive truck farming in the county offers attractive opportunities, as the climate and soils are admirably suited to this type of farming, and much of the land well adapted to trucking close to shipping points may be had at reasonable prices.

SOIL SURVEY OF PINELLAS COUNTY, FLORIDA.

BY

GROVE B. JONES AND T. M. MORRISON.

U. S. DEPARTMENT OF AGRICULTURE,
BUREAU OF SOILS—MILTON WHITNEY, CHIEF.

IN CO-OPERATION WITH THE FLORIDA STATE GEOLOGICAL SURVEY,
E. H. SELLARDS, STATE GEOLOGIST.

HUGH H. BENNETT, INSPECTOR, SOUTHERN DIVISION.

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MAP.

Soil map, Pinellas County sheet, Florida.

SOIL SURVEY OF PINELLAS COUNTY, FLORIDA.*

By Grove B. Jones and T. M. Morrison.

DESCRIPTION OF THE AREA.

Pinellas County is situated on the western coast of Florida, about midway between the northern and southern boundaries of the State, and occupies that section known as Pinellas Peninsula. It is bounded on the north by Pasco County; on the east by Hillsboro County and Tampa and Old Tampa Bays; on the south by Tampa Bay and the Gulf of Mexico; and on the west by the Gulf of Mexico. The total length of boundary of Pinellas mainland is 84 miles, only 18 of which are formed by land. The county is about 34 miles long and 15 miles wide at its widest point. It contains an area of 260 square miles, or 166,400 acres. Besides the mainland the county in-

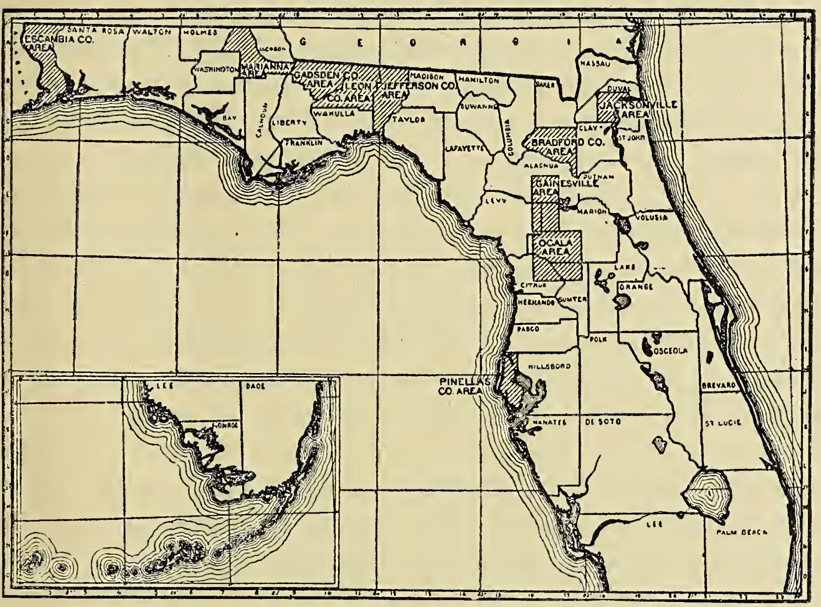

Fig. 72.—Sketch map showing areas surveyed in Florida.

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*An edition of this paper was issued by the U. S. Bureau of Soils, September 30, 1914, as Advance Sheet, Field Operations of the Bureau of Soils, 1913.

cludes a chain of narrow keys and islands lying nearly parallel with the western shore, which gives it approximately 128 miles of water front.

The base map of the county, showing the location of roads, towns, schoolhouses, churches, dwellings, railroads, streams, etc., was made by plane-table traverse as the soil mapping progressed. The county was originally plotted into sections, and although these are not of uniform size, few containing exactly 1 square mile, the base map has been made to conform to these long-established lines.

The level and undulating type of topography characteristic of the Coastal Plain predominates, although in some sections rolling to hilly country exists. The highest elevations are found north of Wall Springs and about the northern end of Lake Butler. Natural drainage is best established in the western part of the county, and this section shows the greatest development. At St. Petersburg and in the vicinity of Green Springs other well-drained areas are found.

The low and poorly drained areas known as "flatwoods" are most extensively developed southeast of Largo, extending nearly to St. Petersburg. These lie only a few feet above sea level and contain numerous water and grass ponds. (See fig. 73.) The few streams are small and sluggish, and during times of heavy rainfall this low-lying land is inundated and remains in a wet condition for a considerable period. South and east of Lake Butler and extending to the Hillsboro County line is another extensive area of poorly drained soils. This differs from the "flatwoods" in the southern part of the county in that it contains no water and grass ponds, but abounds in swamps and depressed areas which support a dense growth of cypress. No cypress trees are found in the southern part of the county.

The shore is indented by many tidewater estuaries and salt marshes. The only stream in the county of any importance is the Anclote River, which has its source in Pasco County. This is a tide-water stream and is navigated by small craft for a considerable distance. Lake Butler, the largest body of water within the boundaries of the county, is 6 miles long and about a mile wide, and has an underground outlet.

Pinellas County, formerly the western portion of Hillsboro County, was organized in November, 1911, and Clearwater, situated about midway on the western coast on Clearwater Harbor, was made the county seat. According to the census of 1910, this town has a population of 1,171, and besides being one of the main shipping points for citrus fruits is fast growing in favor as a winter resort. St. Petersburg, situated in the southeastern part of the county, on Tampa Bay, is the largest town. It has a population of about 4,127 year-round residents. It is widely known as a winter resort, being the largest on the west coast, and during the winter season accommodates as many as 10,000 tourists. It is admirably located for shipping purposes. Largo is a thriving town, lying about 4 miles south of Clearwater. It is the main shipping point for citrus fruit in the county, and handles the products of a large fruit-growing section. Dunedin is a prosperous little town, population 256, beautifully situated on Clearwater Harbor. It is also a shipping point for citrus fruits. Tarpon Springs, population 2,212, the northernmost city on the peninsula, is located on the southern bank of the Anclote River. It is one of the greatest sponge markets in the world, the industry being principally in the hands of Greeks. The yearly sales range from one-half million to a million dollars. A boat-building industry also has been established here. Sutherland, the site of Southern College; Ozona, on the Gulf; Belleair, and Pinellas Park are thriving villages and winter resorts. Green Springs, situated on the eastern coast on Old Tampa Bay, is not only a shipping point for citrus fruits, but is also the site of Espiritu Santo Springs, well known for their medicinal value. Passagrille is a popular Gulf resort located on Long Key. Gulfport, on Boca Ceiga Bay, is a thriving community reached by trolley from St. Petersburg.

The more thickly settled rural districts are supplied with mail routes and telephone service. The school facilities of the county are good, graded schools and high schools being found in the towns and villages.

The Atlantic Coast Line Railroad, which enters the northeastern corner of the county, passes through the towns along the western coast and has St. Petersburg as its southern terminus. The Tampa & Gulf Coast Railroad extends from St. Petersburg, in the southern part of the county, to Clearwater, thence to Espiritu Santo Springs, bearing north, then east and out of the county. A line of the same system runs from Tarpon Springs east, where it makes connections with the Tampa Northern for Tampa and Brooksville. Another branch extends north from Lake Villa to Port Richey, in Pasco County. St. Petersburg is connected with a number of outlying points by electric line. Steamboats ply between St. Petersburg and Tampa and points south.

The county roads have been greatly improved in the last two years, and many old roads are at present being re-established and straightened. There is a stone-surfaced road connecting Largo and Tarpon Springs. Branching from this about a half mile south of Sutherland is the Tampa rock and shell road. Many of the sand roads are improved by the application of pine needles and are known as "straw" roads. A rock and straw road leading east and north from Clearwater through Green Springs joins the Tampa road where the latter crosses Moccasin Branch. The newly laid out roads in the southern part of the peninsula follow the section lines more closely than the older roads, but as yet are unimproved. A hard-surfaced road south from Largo to St. Petersburg is being constructed. As settlement progresses the roads of the county will doubtless be improved, thereby greatly enhancing the value of farm lands.

CLIMATE.

The winter climate of Pinellas County is mild and balmy. December, January, and February have a mean temperature of about 60° F., and light frosts are of frequent occurrence during this period. Killing frosts are not unusual, and disastrous freezes were recorded in 1894, 1895, and 1899. During the mildest winters flowers bloom, and vegetables are grown without protection throughout the season. As a rule vegetables and tender plants are not free from danger of frosts between November 28 and March 24; however, the records at Tampa and Manatee show that killing frosts ordinarily occur only between January 9 and February 8 at the former station and between January 3 and January 26 at the latter.

While the summer temperatures are not regarded as excessive, being moderated by breezes from the surrounding waters, discomfort is often experienced through spells of long-continued heat. June, July, and August, the hottest months, have a mean temperature of about 80° F. The absolute maximum for these months is 96° F., and the absolute minimum 65° F.

The mean annual precipitation at the Tampa station is about 51.5 inches and at Manatee 55.4 inches. The wettest season extends through the months of June, July, and August, and frequently into September. During this period the low-lying lands are inundated and truck crops are seriously affected and in some years even drowned out. On the other hand, during the months of scant rainfall, especially in March, April, and May, crops planted on Norfolk fine sand are apt to suffer from lack of moisture. Irrigation is therefore essential for the greatest success in trucking.

The records of the Weather Bureau stations at Tampa and Manatee, in counties adjoining Pinellas on the east and south, respectively, were taken in preference to those of Tarpon Springs, Pinellas County, as those of the latter station are not complete. The data given are believed to represent local conditions in the county. These tables give the normal monthly, seasonal, and annual temperature and precipitation. The presence of bodies of water on three sides of the county has a moderating effect on the temperature, rendering the summers cooler and the winters warmer than in adjacent inland counties.

Normal monthly, seasonal, and annual temperature and precipitation at Tampa, Hillsboro County, Fla.

Month.	Temperature.			Precipitation.		
	Mean.	Absolute maximum.	Absolute minimum.	Mean.	Total amount for the driest year.	Total amount for the wettest year.
	Deg. F.	Deg. F.	Deg. F.	Inches	Inches	Inches
December	59.5	83	19	2.29	0.39	0.54
January	57.4	82	23	2.56	2.14	1.42
February	60.9	86	22	2.88	1.10	2.73
Winter	59.3			7.73	3.63	4.69
March	65.9	92	32	2.76	0.08	1.71
April	70.6	90	38	1.87	2.07	1.36
May	75.5	94	53	2.73	1.81	6.92
Spring	70.7			7.36	3.96	9.99
June	78.7	95	64	7.58	6.18	9.15
July	80.0	96	65	9.36	2.75	11.56
August	80.0	96	67	9.02	7.48	7.16
Summer	79.6			25.96	16.41	27.87
September	78.3	94	54	6.32	5.73	17.28
October	72.6	93	44	2.41	1.18	4.84
November	65.4	87	32	1.71	1.34	2.26
Fall	72.1			10.44	8.25	24.38
Year	70.4	96	19	51.49	32.25	66 93

Normal monthly, seasonal, and annual temperature and precipitation at Manatee, Manatee County, Fla.

Month.	Temperature.			Precipitation.		
	Mean.	Absolute maximum.	Absolute minimum.	Mean.	Total amount for the driest year.	Total amount for the wettest year.
	Deg. F.	Deg. F.	Deg. F.	Inches	Inches	Inches
December	61.8	85	19	2.37	5.19	4.41
January	60.7	88	20	2.78	0.36	3.36
February	62.3	89	23	3.01	1.40	3.87
Winter	61.6	--------	--------	8.16	6.95	11.64
March	66.6	90	31	2.71	0.00	8.59
April	70.6	92	39	1.91	1.84	3.20
May	76.2	97	47	2.92	2.54	4.13
Spring	71.1	--------	--------	7.54	4.38	15.92
June	80.1	100	59	7.80	8.11	9.23
July	81.0	99	61	10.84	6.46	11.05
August	81.2	96	65	9.16	6.73	15.45
Summer	80.8	--------	--------	27.80	21.30	35.73
September	80.0	97	56	7.57	6.12	6.64
October	73.9	93	39	2.71	1.55	3.30
November	67.1	88	29	1.62	1.14	2.55
Fall	73.7	--------	--------	11.90	8.81	12.49
Year	71.8	100	19	55.40	41.44	75.78

AGRICULTURE.

In Pinellas County citrus fruit growing is the principal industry and little attention is at present paid to general farming or other forms of agriculture.

Cotton and corn were grown quite generally in the early days and a considerable acreage was devoted to these crops for a period following the disastrous freeze of 1895, which seriously injured the citrus trees. This practice continued, however, only while the groves were recuperating.

The growing of citrus fruits has been carried on for some time in Pinellas County and each year the acreage in groves increases. As a result land values have advanced sharply in recent years. The Norfolk fine sand, or "piny-woods land," is generally recognized as the best soil in the county for growing citrus fruits, and all the profitable and well-established groves are situated on this type. (Figure 74.) This soil occupies an area of 61.5 square miles. Since most of this can be successfully used for citrus fruits, there is opportunity for a considerable extension of the industry, as probably not more than 10 per cent is at present used for fruit growing. The other soils are either too wet or too droughty for orange culture.

Groves ordinarily vary in size from 10 to 30 acres. Larger groves, usually controlled by companies, frequently contain a hundred acres or more.

All the old groves are "seedling groves," while the young orchards consist entirely of budded stock. Seedlings, as a rule, are irregular in yield, seldom having two large yields of fruit in succession. They also are said to require more fertilizer than budded trees.

The native forest growth on the Norfolk fine sand consists principally of longleaf pine, which should be removed before the land is used for orange culture. The cost of clearing ranges from $20 to $75 an acre, depending upon the growth and the method employed. Sawmill companies frequently buy the standing timber at $8 to $15 an acre. The tops of trees and those undesirable for lumber may be cut into cordwood, which sells for $2 to $3 a cord.

Stumps are either burned or cut out and frequently dynamite is employed. Considerable land is cleared by contract, which includes the removal of all timber growth and the grubbing out of all underbrush.

In some instances groves have been planted in clearings where the pines have been girdled and left standing. This is not a good plan, for when the dead pines are later removed or blown down the young fruit trees are not infrequently injured. The dead trees also serve as a breeding place for wood-lice and other insects injurious to young citrus trees.

The price of land planted in citrus fruits depends upon the age of the trees, varieties, location, improvements, etc., and ranges from $300 to $1,000 or more an acre.

While the rainfall is usually sufficient to produce the citrus fruits, irrigation is sometimes practiced. A few groves are equipped with the Skinner overhead system. Some means of irrigating the trees will be found especially valuable in the areas mapped as the hilly phase of the Norfolk fine sand, around Tarpon Springs and east of this point.

Besides the orange, the pomelo (grapefruit) is produced commercially. The latter is said to be even more profitable than the orange. The shaddock, lime, and lemon are grown only as ornamentals or novelties.

The prices paid for citrus fruits vary from year to year, and during the different periods of the same season. Early oranges bring from 75 cents to $1.50 a box, and late oranges, principally the Tardiff, from $1.50 to $2 or even more a box. The price of grapefruit ranges from $1.50 to $3 a box.

Besides the production of citrus fruits some attention is paid to trucking, but this industry has not been developed along commercial lines to any great extent. Many different vegetables are grown for home use and for the local markets. The latter are not at all times supplied, and there appears to be opportunity for some extension of the trucking industry, especially during the winter months, when the local demand is greatest.

Cucumbers are grown to some extent for shipping and when not injured by fungous diseases prove a very profitable crop. Both the Norfolk fine sand and the well-drained Portsmouth fine sand are suited to this crop. Small shipments of other vegetables are not infrequently made, but these are exceptional. Cabbage may be grown during the winter months, but the more tender vegetables are frequently injured by frost as late as February. This winter (1912-13) the most tender vegetables and foliage were uninjured by frost and grew luxuriantly without protection.

Tomatoes, English peas, early Irish potatoes, snap beans, eggplant, peppers, okra, squash, lettuce, and radishes all do well. Heavy applications of commercial fertilizer or barnyard manure are required, and in order to secure best results some form of irrigation is necessary.

The growing of celery would doubtless prove remunerative as the Muck soils of the county are well suited to its production. Irish potatoes also do well on the same land. Sweet potatoes are grown on the Norfolk fine sand. Watermelons and cantaloupes are grown principally for home markets, although some watermelons have been shipped to outside markets. The Norfolk fine sand is especially well suited to their production.

Sugar cane is grown to a limited extent by nearly every farmer, chiefly for the manufacture of sirup for home use. A few planters produce some for the local markets. The county embraces large areas of land well suited to the growing of this crop, and the production of sirup on a commercial basis may prove a profitable industry. The Norfolk fine sand, flat phase, is the best soil of the county for the production of sugar cane, the sirup being of excellent quality. The deeper phase of this type produces a very desirable sirup, but the yield is not so large, and heavier applications of fertilizers are required. Heavy yields of sirup are secured on the Portsmouth fine sand, but usually the quality does not equal that produced on the Norfolk soil. The Parkwood fine sandy loam and silty clay loam and the Fellowship fine sandy loam are highly adapted to this crop, but as a rule dark-colored soils do not produce as bright sirup as lighter colored soils.

Sugar cane is planted in rows or on ridges, usually 5 feet apart. Sections of the cane stalk about 18 inches long are laid end to end and then covered with 3 or 4 inches of soil. Planting is usually done in January. Various brands of commercial fertilizers are used, as well as cottonseed meal and barnyard manure. The time of applying and the amounts used vary. Some growers apply stable manure to the land about two weeks before planting and follow this up with 1,000 pounds of cottonseed meal per acre, in two equal applications, the first half when the cane is sufficiently high to cultivate and the remainder when the crop is ready to lay by.

Another method of procedure in fertilizing sugar cane is to apply 800 pounds of commercial fertilizer (analyzing approximately 7 per cent phosphoric acid, 3 per cent nitrogen, 4 per cent potash) at seeding time, followed by two applications, each of 200 pounds, of cottonseed meal, when the cane has attained a height of 2 feet and 4 feet, respectively. Muriate of potash should not be included in cane fertilizers on account of its tendency to give the sirup an unpleasant chlorine or salty taste.

The Japanese, Red, and other varieties of sugar cane are grown. The yields of sirup range from 250 to 400 gallons per acre, and the price varies from 50 to 80 cents a gallon.

Strawberries do well on the better drained Portsmouth fine sand and the Norfolk fine sand, flat phase, and thoroughly drained Muck. The demands of the local markets are far from being supplied, and the growing of strawberries would prove decidedly profitable. The Klondike, Missionary, Lady Thomson (an early variety), Excelsior, and other varieties are grown.

Guavas are grown to some extent for home use, usually appearing in the yard as an ornamental shrub. Some of the fruit is canned, but its chief usefulness is in the making of jelly.

Wild varieties of blackberries and dewberries grow abundantly, but there has been no attempt to produce the cultivated varieties. The Scuppernong grape does well and is found in nearly every yard.

Peaches and plums are grown to some extent, but the results can not be said to be satisfactory. The peach tree is short lived, and the yields are uncertain. The South China type of peach probably does better than any other. It ripens early and is of good quality and flavor.

The pomegranate, grown usually as an ornamental shrub, gives an abundant yield and can be grown with but little attention. The fruit is used in making jellies, marmalades, and acid drinks. It would seem to have commercial possibilities in the county.

The Japanese persimmon is grown only as an ornament or novelty, and the fruit is not held in high favor. Figs are not grown. The avocado, or alligator pear, is grown simply as a novelty.

Pineapples were at one time successfully produced under shade at Clearwater. Some were seen growing near Green Springs under shade, but more as an experiment than for profit.

The pecan industry has not been developed in Pinellas County, although the tree thrives in the climate and soil of this region. A few bearing trees of considerable size and thrift indicate what may be expected of the few young trees just approaching the bearing stage. The Norfolk fine sand is thought to be the soil best suited for the pecan in this region.

Small patches of corn are grown by a few farmers. The harvested corn is usually badly damaged by the weevil. It is the general practice to buy all feeds for stock and it is considered cheaper than to attempt to produce them locally. However, a number of forage crops can be grown, and if given as much attention as is given to citrus fruits they should give profitable returns.

Oats do well on the Norfolk fine sand, and when cut either in the milk stage or when ripe make a splendid feed. Spanish peanut vine hay is considered locally the best hay for all purposes. Beggarweed, crab grass, and sandspur are also valuable hay crops. Crab grass is cut to a considerable extent from the groves and forms the bulk of the hay produced. Beggarweed when once started reseeds each year. It makes a good hay, and when turned under is a good fertilizer.

Cowpeas and sorghum sown together make a nutritious feed. Hairy vetch has been successfully grown, the best results being obtained when broadcasted with cowpeas.

Chufas, for fattening hogs, grow more satisfactorily than the peanut, which does not always fill out unless limed. Cassava is another good feed for hogs, and it seems it should find greater favor with those who produce pork for the market. Velvet beans produce a large quantity of vine hay and are grown to some extent. They do especially well on the Norfolk fine sand, and besides affording an abundance of feed, are an excellent soil renovator. Japan clover is another leguminous plant which does well locally, and besides making a fine quality of hay, affords good pasturage.

These and other forage crops can be cheaply produced and should be an incentive for the raising of dairy and beef cattle. Dairy farming should prove a profitable business in Pinellas County. The only existing dairies, located near the larger towns, do not begin to supply the demand, especially during the winter months, when it is greatest. There are some Jersey and Guernsey cows in the herds. Sweet milk finds a ready market at 12½ cents to 14 cents a quart, and butter brings from 40 to 50 cents a pound.

Large tracts of land are owned or controlled by companies and land syndicates which place their holdings on the market in tracts varying from 10 to 30 acres. The price ranges from $25 to $75 an acre for Portsmouth fine sand (truck soils) to $50 to $150 an acre for unimproved Norfolk fine sand (fruit land).

So much depends upon the proper selection of the type of soil best suited and adapted to certain crops that it behooves the intending purchaser personally to inspect the land he contemplates buying, whether it be for the growing of citrus fruits or for trucking. Drainage is the main thing to be considered, and this should be determined, not during the dry months, but when the rainy period is at its height. The Norfolk fine sand and Leon fine sand, rolling phase, are the only soils that have adequate natural drainage. In the better drained situations of the Portsmouth fine sand crops may be grown successfully without the aid of artificial drainage, but the greater part of the type must be drained to produce crops successfully. The Parkwood, Plummer, and Fellowship soils can not be utilized in their present condition.

SOILS.

The underlying geological formations of Pinellas County belong to the Upper Oligocene. These are exposed at a number of different points in the county. At Bay View and a few other places the exposures consist of a hard impure limestone, while in other places plastic dark-colored clays are found. These materials, however, influence the soil in but a comparatively small part of the county.

The county as a whole is covered with a mantle of fine sand several feet in thickness. At Clearwater the bluff along the bay exposes a section of this deposit, which shows it to be 12 to 15 feet thick. The deposit is deepest in the northern part of the county and in many places gives evidence of having been drifted about by the wind. This action, together with the uneven dissolution of the underlying limestone, has given the region a more varied topography than is found farther south. Most of the soils have been derived from this sandy deposit.

Difference in topography and depth of the sandy mantle has given rise to two broad groups of soils—those that are well drained and those having poor natural drainage. The poorly drained soils predominate in number and extent, there being but two types that have ample natural drainage—the Norfolk fine sand and the Leon fine sand. The surface soils of the county are fine in texture, and with one exception—a silty clay loam of small development—they fall into two classes: The fine sand and fine sandy loam.

The soils of Pinellas County are in general designated by local terms descriptive of their topographic features and forest growth. To the highest and excessively drained types the term "sand hill" is applied. The forest growth, now almost entirely removed, originally consisted of longleaf pine. Blackjack oak has taken possession of some of this land. The hilly phase of the Norfolk fine sand occupies these elevations.

"Scrub" is a local term given to hills and ridges of the Leon fine sand, rolling phase. It supports a dense growth of shortleaf pine, locally called "spruce pine," and a thick undergrowth of rosemary, palmetto, and low-growing shrubs and vines, and has a very low agricultural value.

"Piny woods land" and "high hammock land" are equivalent terms used to designate that class of land in which drainage is sufficiently well established to permit citrus fruit growing, and other forms of agriculture. Vegetation on such areas consists of longleaf pine, scattering blackjack oak, clumps of live oak and saw palmetto, wire grass, myrtle, some "oak runners," and gallberry in the depressed positions.

This local classification includes the typical Norfolk fine sand, and frequently the flat phase of this type, although the latter is often referred to as "hammock land," on account of its level surface and dark color.

"Low hammock" applies to low semi-swampy areas occupied by the Parkwood series, of which there are two members, the fine sandy loam and silty clay loam. These soils are dark colored and have a marly subsoil, but owing to their swampy nature have not been developed agriculturally.

"Bays" and "bay heads" are wet, swampy depressions, in which the accumulation of decaying vegetable material is continually in progress, forming muck and peat.

The "flatwoods" constitute the low-lying, nearly level areas in which drainage is immaturely established. After heavy rainfall water remains on the surface for several days and the soil continues in a saturated condition for a considerable period. The Portsmouth fine sand is the typical soil of the "flatwoods," although it is found also on slopes and in depressions in higher lying country. The surface soil is a dark fine sand containing a high percentage of organic matter, which is usually underlain at about 2 feet by a brown substratum known as "hardpan." This compact layer, consisting of sand cemented or made compact by iron salts and organic matter, varies from a few inches to a foot or more in thickness and is found at the permanent water-table level. The hardpan lies at a remarkably uniform depth throughout the flatwoods, where the more extensive and more typical areas of the Portsmouth fine sand occur. It doubtless prevents to a considerable degree the free movement of soil moisture. It is not readily penetrated by tree roots, as is evidenced by the shorter growth and gnarly, spreading tops of pine trees. Saw palmetto grows in profusion and in lower lying areas gallberry is found. The swamp phase of the Portsmouth fine sand is confined entirely to the numerous cypress ponds that occupy the low depressions. These are either covered with water or are in a saturated condition the year around. Other low areas are shown on the map as water and grass areas. They have no tree growth, but support a fresh-water vegetation consisting of reeds, rushes, grasses, and lilies. Both the cypress ponds and these water and grass ponds, as well as the lakes and clear water ponds of the county, have probably resulted through the formation of basins by the solution of underlying limestone.

The Leon fine sand is a flatwoods type occupying a position slightly elevated above the Portsmouth fine sand. It is excessively drained, except at times of heavy rainfall, when it is usually covered with water. The objectionable hardpan is present, which adds to the low productiveness of the soil. Longleaf pine, scrub palmetto, wire grass, and "oak runners" constitute the characteristic vegetation.

The Fellowship series, represented only by the fine sandy loam, occupies a position in the flatwoods similar to that of the Portsmouth fine sand. The surface, dark with organic matter, is underlain by orange and ocherous fine sand, grading into similar colored fine sandy clay. Beneath this is found shell fragments and shell limestone. The material, of the subsoil at least, may be partly residual in origin. The marly character of the subsoil of the Parkwood soils is thought to represent a more advanced stage in the decomposition of the underlying marine deposits than is found beneath the Fellowship fine sandy loam. The vegetation is the same as on the Fellowship and Portsmouth soils.

The Plummer fine sand occupies low, flat semiswampy areas which are at present of no agricultural value. Water stands on the greater part of the type much of the time and cypress is the main tree growth. In many respects the Plummer fine sand closely resembles the more recent deposit of Tidal marsh, which is still in process of formation, and may be closely related to it in origin.

In mapping Swamp the classification has been confined to low-lying areas along stream courses and bordering the larger bodies of fresh water. Swamp material varies considerably, but a great deal of it consists of areas of muck and peat too low lying and wet to be of any value in their present condition.

Coastal beach is a self-explanatory term. It consists of sand and shells and is unsuited for agriculture.

Including Coastal beach, Tidal marsh, Muck, and Swamp as types, 11 types of soils were mapped, and several type phases were recognized.

The following table gives the name and actual and relative extent of each soil mapped in Pinellas County:

ILLUSTRATIONS
TO ACCOMPANY THE
SOIL SURVEY OF PINELLAS COUNTY.
FIGURES 73 TO 80.

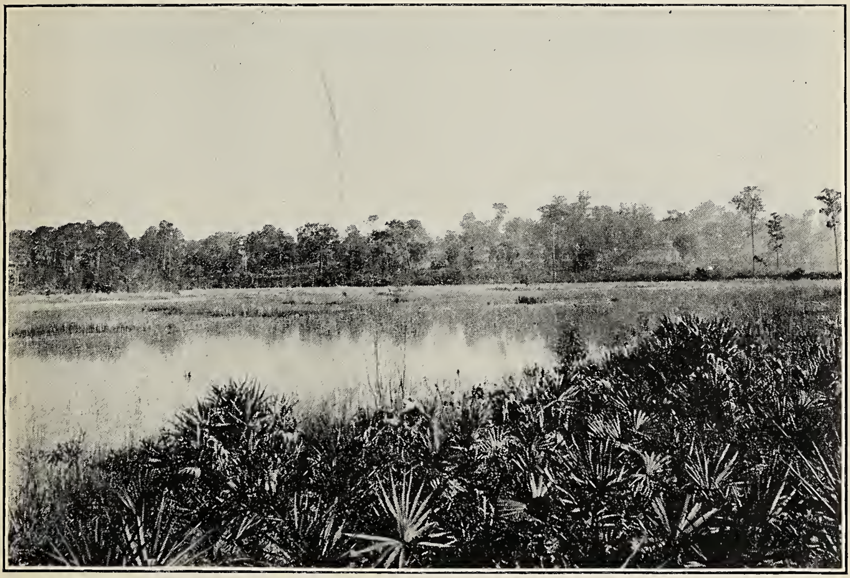


Fig. 73.—One of the larger water and grass ponds, east of Tarpon Springs. Portsmouth fine sand in foreground; hilly fine sand in background.

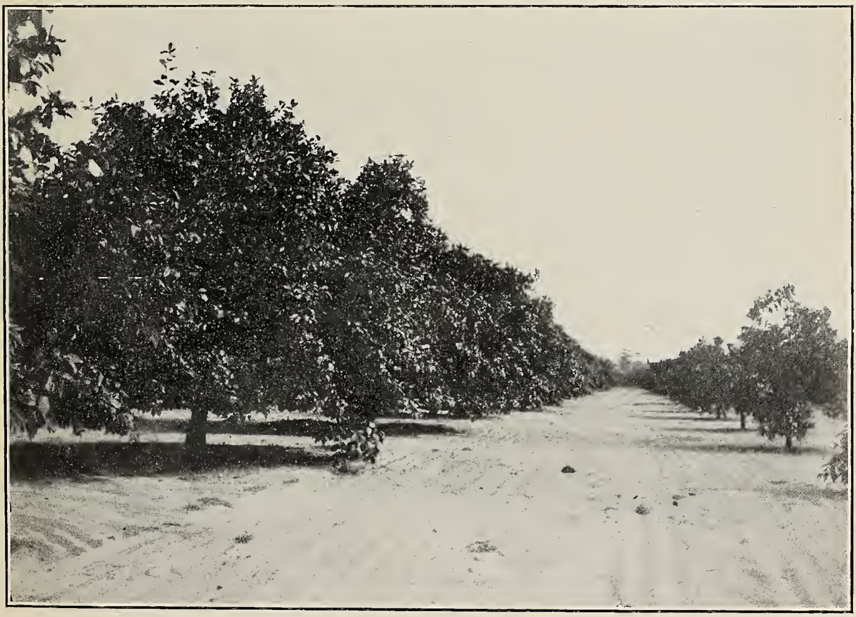


Fig. 74.—Orange grove on Norfolk fine sand, east of Belleair, showing clean cultivation.

Fig. 75.—View showing abrupt change from Portsmouth fine sand to Norfolk fine sand. The saw palmetto growing on the former soil.

Fig. 76.—Characteristic topography and growth, Norfolk fine sand.

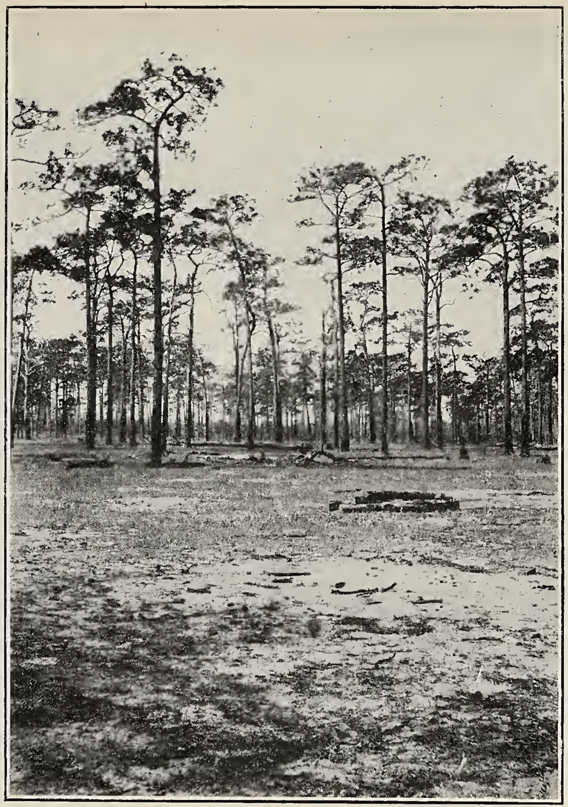
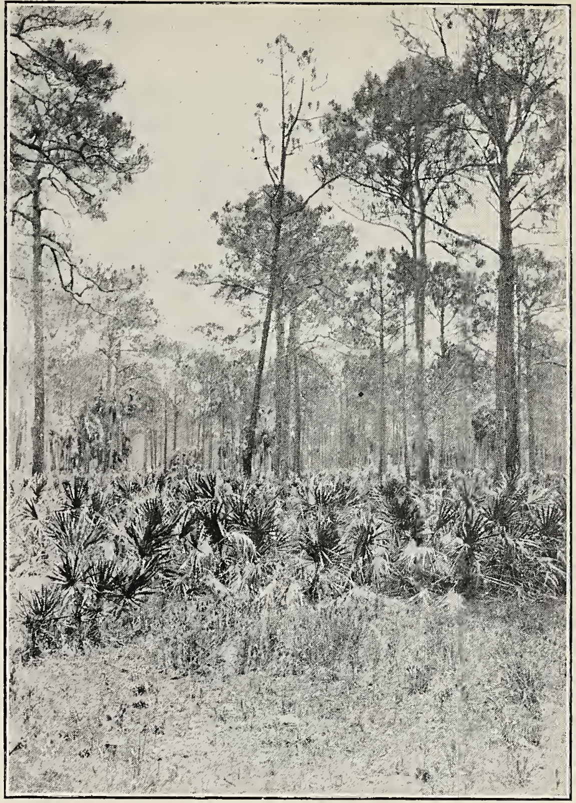


Fig. 77.—Portsmouth fine sand, swamp phase, locally known as "cypress ponds."

Fig. 78.—Characteristic growth on Leon fine sand, rolling phase, east of Clearwater.

Fig. 79.—Parkwood fine sandy loam, showing character of vegetation on uncleared portion.



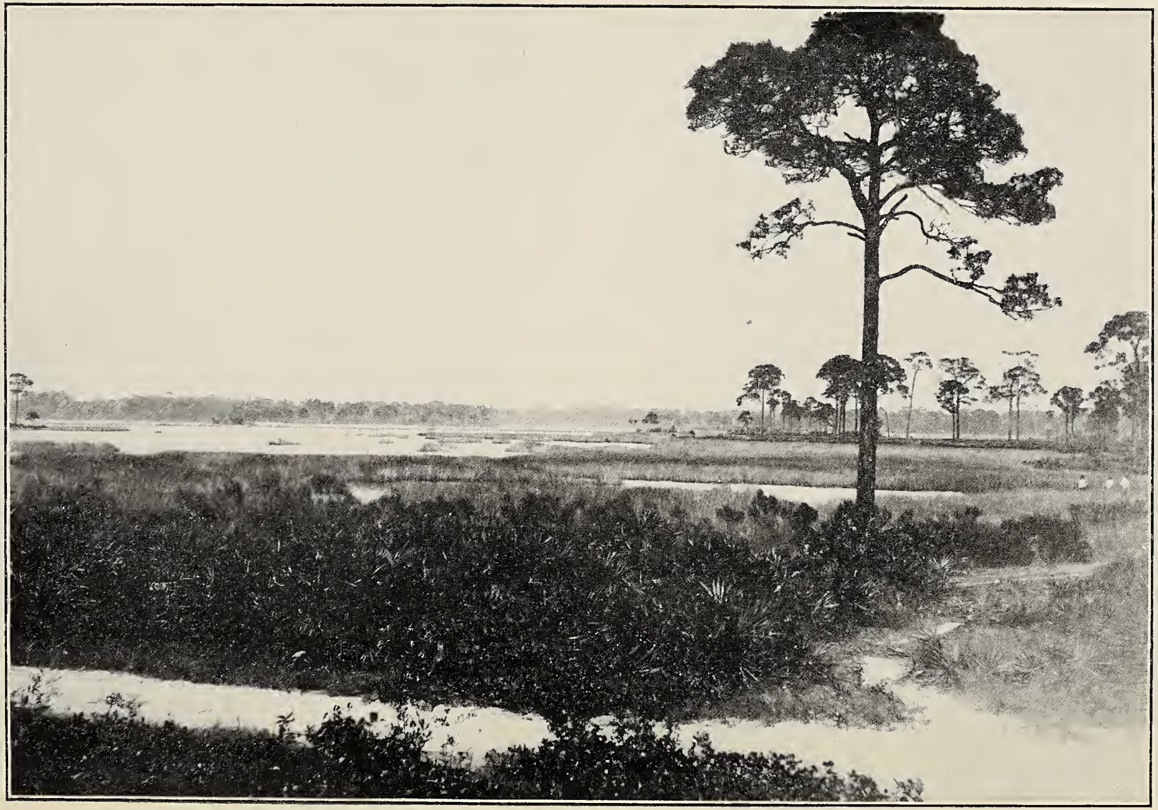


Fig. 80.—Tidal marsh between Ozona and Sutherland.

Areas of different soils.

Soil	Acres	Per ct.
Portsmouth fine sand	65,088	40.7
Swamp phase	2,624	
Norfolk fine sand	32,832	23.6
Flat phase	4,224	
Hilly phase	2,304	
Leon fine sand	21,056	16.7
Rolling phase	6,592	
Fellowship fine sandy loam	7,680	4.6
Coastal beach	6,784	4.1
Plummer fine sand	4,736	2.8
Muck	4,608	2.7
Swamp	4,288	2.6
Tidal marsh	3,264	2.0
Parkwood fine sandy loam	256	.1
Parkwood silty clay loam	64	.1
Total	166,400	

GRAY SOILS.

SEDIMENTARY MATERIAL—SANDS AND CLAYS.

NORFOLK SERIES.

The Norfolk soils are characterized by the light-gray to grayish-yellow color of the surface soils, and by the yellow color and friable structure of the subsoils. They occupy nearly level to rolling uplands throughout the Atlantic and Gulf Coastal Plain, and have been derived from unconsolidated Coastal Plain deposits.

NORFOLK FINE SAND.

The Norfolk fine sand consists of gray or brownish-gray fine sand, 6 to 8 inches deep, underlain by a yellow or pale-yellow fine sand of rather loose texture. The grayish color of the surface soil is due to the presence of organic matter, which is present in sufficient quantity to make it more loamy in texture than the subsoil.

The Norfolk fine sand is found principally in the western half of the county. It is also well developed in the vicinity of Green Springs and St. Petersburg.

The surface ranges from nearly level or gently undulating to rolling. The land is thoroughly drained, but the texture of the soil is fine enough to make it retentive of moisture and crops are affected but little by ordinary periods of drought.

This is the most important and highest priced soil in Pinellas County. It is especially well adapted and extensively used for growing oranges and grapefruit. It is also well adapted to the production of truck crops, such as Irish potatoes, sweet potatoes, English peas, radishes, onions, lettuce, snap beans, peppers, eggplant, tomatoes, cucumbers, watermelons, and cantaloupes. Peaches and plums are grown to a limited extent, but the trees are usually short lived and the fruit of an inferior quality. The pecan trees seen were in a thrifty condition.

A few patches of velvet beans have been grown. This crop seems to be better suited to the type, under local conditions, than any other of the leguminous crops. Cowpeas also do well and beggarweed once started reseeds itself.

Both in citrus fruit and truck growing commercial fertilizers are used. Commercial fertilizers are found more beneficial and lasting in their effect if the soil contains a reasonable amount of organic matter.

The principal tree growth on this type is longleaf pine. An occasional clump of live oak is found and in places scattering blackjack oak. The undergrowth consists mainly of wire grass and patches of oak runner, with occasional clusters of saw palmetto. (Figs. 75 and 76.)

Unimproved tracts of land of this type of soil range in price from $30 to $150 an acre, the difference depending upon location. It is said to cost from $250 to $400 to clear, fence, and plant an acre in oranges or grapefruit. Groves in good bearing are valued at $500 to $1,000 or more an acre.

Norfolk fine sand, flat phase.—The Norfolk fine sand, flat phase, consists of a dark-gray to nearly black fine sand, underlain at 3 to 6 inches by light-gray fine sand, which grades below into yellow or yellowish-gray fine sand. The darker color and more loamy texture of the surface soil are due to a higher organic content than is present in the typical soil. The subsoil is almost identical with that of the typical soil both in color and texture.

This phase of the Norfolk fine sand, known locally as "hammock land," occupies a position intermediate between the Portsmouth fine sand and the typical Norfolk fine sand. It has a nearly level surface. The principal areas occur south of Largo.

The vegetation consists of longleaf pine, wire grass, and saw palmetto. Natural drainage for the most part is fairly well established and only a small proportion of the area would be benefited by ditching or tiling. On the other hand, the presence of a high percentage of humus in the surface soil, together with the open-textured subsoil, assists in the conservation of moisture.

The Norfolk fine sand, flat phase, is very well adapted to the growing of citrus fruits, some of the best paying groves in the county being located on it.

Vegetables of all kinds do exceptionally well, and there is less danger of damage from drought than on the typical soil. Taken as a whole, this soil is the best in the county. It is better suited to a wide range of crops, and is the most certain to produce good average yields. Its smooth surface fits it for the use of labor-saving machinery.

The value of unimproved land of the flat phase of the Norfolk fine sand ranges from $60 to $150 an acre.

Norfolk fine sand, hilly phase.—The Norfolk fine sand, hilly phase, locally called "sand hills," consists of a few inches of light-gray fine sand resting on a subsoil of light-yellow fine sand, which extends to a depth of several feet. The structure of both soil and subsoil is rather incoherent, and except for the darker surface, there is little variation within the 3-foot section.

The Norfolk fine sand, hilly phase, is confined entirely to the northern part of the county. It appears north of Wall Springs and extends around the north end of Lake Butler. East of the lake are a few ridges and hillocks which have the form of dunes.

The phase is excessively drained, and no attempts have been successfully made to cultivate the higher lying portions. On account of its uneven surface, irrigation for much of this phase would be impracticable and in some locations impossible. Irrigation, nevertheless, would be necessary to prevent crops from burning out during periods of scanty rainfall.

Nearly all of the longleaf pine from this phase of the Norfolk fine sand has been removed. The present growth consists of black-jack oak, occasional clumps of live oak, and scattering longleaf pine.

Areas of Norfolk fine sand, hilly phase, are placed on the market in small tracts at $25 to $50 and more an acre.

LEON SERIES.

This series comprises the loose, light-gray to white sandy soils of the South Atlantic and East Gulf coast flatwoods region, which in their typical development have a subsurface hardpan stratum, encountered usually at a depth of 12 to 24 inches. This stratum averages from 8 to 10 inches in thickness and consists of a compact layer of fine sand or sand ranging in color from black to dark rusty brown in the upper 2 or 3 inches to rusty brown or slightly darker in the lower portion. It becomes less compact and lighter in color as the lower part of the stratum is approached, a white sand being frequently encountered underlying the stratum and within the 3-foot section. The material of this layer runs high in organic matter and very low in iron, and although the rusty brown color would suggest cementation with iron the analyses indicate that the compactness is due to the presence of organic matter. The substratum is lacking in some phases.

LEON FINE SAND.

The surface soil of the Leon fine sand consists of from 4 to 6 inches of light-gray or white fine sand, frequently containing sufficient organic matter to give it a dark-gray color. To an average depth of 28 inches an incoherent, white fine sand practically free from humus is found, usually resting upon a stratum of hardpan. This hardpan stratum is a compact layer of fine sand of varying thickness, containing considerable organic matter. The upper part of the stratum is dark brown to almost black, the material grading into brown, looser fine sand below. In some localities this hardpan is not encountered within the 3-foot section.

The type occupies level to gently undulating country. The natural drainage is poor, partly on account of the level surface and partly as a result of the underlying hardpan, which doubtless hinders to a greater or less extent the free movement of soil moisture, rendering the soil wetter in rainy seasons and more droughty in dry seasons. This is one of the "flatwoods" soils. It is usually associated with the Portsmouth fine sand, but occupies a slightly higher position.

The forest growth consists of scattering longleaf pine and scrub oak. Besides this it supports also a thick growth of palmetto, gallberry, myrtle, oak-runner, and wire grass. It is generally considered an unproductive soil and practically no attempt has been made to place it under cultivation.

Leon fine sand, rolling phase.—The surface 4 inches of the Leon fine sand, rolling phase, is a light-gray fine sand, resting on a white fine sand to a depth of 3 feet or more. Several feet below the surface there is frequently encountered a layer of pale-yellow sand of similar texture. The material consists almost wholly of quartz particles. Besides the difference in topography the rolling phase departs from the typical soil in that the usual hardpan stratum is not found within the 3-foot profile.

The rolling phase is not extensive; neither is it restricted to any particular locality. This land stands somewhat higher than the Portsmouth fine sand, frequently occupying a slight elevation along the water front. It is locally known as "scrub," because of the dense growth of spruce pine which is found in the county only upon this type. Scrub oak, dwarf palmetto, and rosemary constitute a thick undergrowth. (Figure 78.) On account of the position of the type and its loose, porous character, the natural drainage is excessive. As a result little organic matter has accumulated. The topography in places closely resembles that of the sand dunes, and its origin is probably due in part at least to wind action.*

None of the Leon fine sand, rolling phase, is under cultivation, but it is believed that with proper management it would prove a desirable soil for the growing of pineapples. In the southern part of the State pineapples are successfully grown on soil similar to this, but no attempt has been made to produce them here.

Parkwood Series.

The distinguishing feature of the Parkwood series is the gray to white lower subsoil of marl. The soils are grayish to grayish brown in color, with subsoils of grayish-brown to grayish-yellow sandy clay to heavy clay loam in the upper portion, resting upon beds of marl at a depth of 29 inches.

PARKWOOD FINE SANDY LOAM.

The Parkwood fine sandy loam as mapped presents considerable variation. The soil as mapped in this survey consists of a black or nearly black fine sandy loam, being darker than usual. It is underlain by grayish-brown to nearly white silty clay loam containing some calcareous material from limestone or marl. The subsoil in places is a mottled dull-brown and yellow plastic clay or sandy clay. It also in places carries a greenish-yellow material, which probably consists of bog-iron ore. As mapped, the type includes patches in which the soil varies from dark-gray fine sand to black heavy fine sandy loam, ranging from a few inches to about 30 inches in depth. Limestone or marl, with shells, occurs in places within the 3-foot section and occasionally outcrops. The clayey material is derived from the marl or limestone. The type occupies a position intermediate between the heavier Parkwood soils and the sandy types such as the Portsmouth fine sand. The sandy surface material largely represents originally unconsolidated Coastal Plain deposits. Shells are often scattered throughout the soil and subsoil.

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*In the opinion of E. H. Sellards, State geologist, the areas east of Clearwater are old sand dunes.

In Pinellas County the Parkwood fine sandy loam was found to be of small extent, being confined to a few bodies of a total area of 256 acres. One of the larger of these areas lies one-half mile north of Maximo Point. Another is situated 1½ miles south of Ulmerton. The other areas, which are of considerably smaller extent, occur as islands in a water and grass pond near Pinellas Park. It appears that the two larger areas of Parkwood fine sandy loam represent old inland tidewater basins.

Cabbage palmetto, dense clumps of saw palmetto, saw grass, bulrushes, myrtle, and pine constitute the natural vegetation on this type. Figure 79 shows the character of vegetation on uncleared portions.

None of the Parkwood fine sandy loam is at present under cultivation, although attempts have been made in the past to utilize it. Owing to its low-lying position and its somewhat impervious subsoil, the type is badly in need of drainage. The soil, however, is naturally productive and, owing to its marl content, free from any trace of acidity. It has been found elsewhere in the State to be adapted to truck crops, especially cabbage, tomatoes, and Irish potatoes, and there is apparently no reason why it should not be used locally for the production of these crops.

PARKWOOD SILTY CLAY LOAM.

The typical soil of the Parkwood silty clay loam is an ashy-gray or drab silty clay loam, passing below into lighter drab to nearly white, heavy silty clay loam, containing a considerable quantity of white lime concretions, shells or fragments of shells, and partially decomposed material from limestone. The type shows some variations from this typical description. In places the soil consists of black or dark-gray loam to silty clay loam, which may either grade below into drab or nearly white material like the typical subsoil, or into mottled drab and yellow or greenish-yellow plastic clay or sandy clay. Limestone and marl come within the 3-foot section in places, and sometimes outcrop at the surface. Where this limestone is exposed it becomes hard and flinty.

The Parkwood silty clay loam is residual in origin and has been derived from the underlying soft and impure limestone and deposits of marl. It occupies poorly drained depressions and flats. The natural vegetation consists of live oak, water oak, white oak, myrtle, bay, sweet gum, and cabbage and saw palmetto.

Only one area of Parkwood silty clay loam was mapped in the county. It is situated in the southern part of the county at the western end of Salt Lake. It is neither cleared nor under cultivation, and better drainage will have to be established before it can be used for agriculture. In the vicinity of Coleman, Fla., the same type of soil has been found to be productive where good drainage has been established. It is used there in growing citrus fruits, which are of good quality, and for trucking, tomatoes and cabbage being the important crops.

Plummer Series.

The soils of this series are gray and frequently mottled with dark-brownish colors and underlain at a depth varying from 8 to 20 inches by compact, light-gray material more or less mottled with streaks of brown and yellow. The lower portion of the subsoil usually consists of sandy clay or sticky sandy material, including pockets or layers of yellowish, plastic sandy clay. The soils are derived from reworked Piedmont-Appalachian material. They are nearly always in a sticky condition, water frequently standing on the surface after heavy rains. A scattered growth of cypress and pine, and occasionally cabbage palmetto constitutes the principal tree growth. This series is typically developed in the flatwoods region of the South Atlantic and Gulf Coastal Plain.

PLUMMER FINE SAND.

The Plummer fine sand consists of a brownish-gray to whitish fine sand, from 8 to 15 inches deep, underlain by a brown or brownish-gray fine sand to a depth of 36 inches.

A thin layer of material—accumulated deposits of material resulting from repeated inundations—gives the immediate surface a dark color. Upon drying this layer cracks and curls and is very brittle and friable.

The plummer fine sand is confined to the northeastern part of the county. It occurs as flat areas in which are found many shallow depressions and ponds separated from one another by slightly higher, narrow bodies of land.

In wet seasons the entire type is covered with water and not infrequently water remains in the ponds the greater part of the year.

There is no textural difference in the typical soil and that of the included ponds, but it is not uncommon to find the soil in the latter lighter in color. The ponds support a heavy growth of cypress, but in the less depressed areas the timber growth is more scattered and consists of mixed longleaf pine and cypress. The areas also support a good growth of coarse grasses. The slightly depressed areas which are narrow and winding closely resemble shallow stream channels and probably represent the floors of ancient lagoons or sounds.

The higher lying areas of Plummer fine sand support a light growth of longleaf pine. A scattering growth of scrub palmetto is also present, but this is not characteristic of the type and occurs only where small areas of Portsmouth fine sand were of necessity included in the Plummer fine sand.

Owing to poor drainage, none of this type is at present under cultivation, and in its present state it is of no agricultural value except for pasture.

BLACK SOILS.

SEDIMENTARY MATERIAL—SANDS AND CLAYS.

Portsmouth Series.

The soils are dark gray to black, and are high in organic matter. The subsoils are light gray to mottled gray and yellow, and the heavier members are always plastic, though usually carrying a noticeable amount of sand. These soils are developed in flat to slightly depressed, poorly drained situations, and require ditching before they can be used for agriculture. The series is most extensively developed in the flatwoods, or the low region of the Coastal Plain, east of the Mississippi River.

PORTSMOUTH FINE SAND.

The surface soil of the Portsmouth fine sand, as typically developed, consists of a dark-gray or black fine sand, with an average depth of 10 inches and containing considerable organic matter. The subsoil is a light-gray fine sand. practically free from humus, passing at about 24 inches into a hardpan stratum. This layer sometimes lies directly beneath the dark surface soil, while in other places it is either separated from the dark surface soil by a layer of gray or white fine sand of varying thickness or is not developed at all within the 3-foot section. The stratum is composed of a compact fine sand carrying considerable organic matter. The color is usually dark brown to almost black in the upper part and of a lighter brown or coffee-grounds color beneath. The color is imparted by organic matter. Sometimes the material is underlain within the 3-foot section by gray or white sand, but infrequently it continues to a depth of considerably more than 3 feet. On account of its compact nature, this layer is said to be impervious to water, checking underdrainage in wet seasons and retarding the upward capillary movement of moisture in dry seasons.

This is the principal soil of the "flatwoods" section. It is most extensively developed in the eastern half of the county. Large areas occur southeast of Largo, extending toward St. Petersburg, and to the north and west of Green Springs. Numerous water and grass ponds occur in the development of this type southeast of Largo, while in the areas farther north the level topography is varied by innumerable cypress ponds, many too small to be mapped.

The type also occurs on gentle slopes where the land is equally as wet and sometimes even more completely saturated than that of the flatwoods. There is considerable seepage on these slopes, probably on account of the resistance offered underdrainage by the hardpan layer. The soil of such slope situations is frequently black to a depth of 15 inches or more.

The characteristic growth on the Portsmouth fine sand consists of longleaf pine, saw palmetto, myrtle, and gallberry. Saw palmetto is an indication of the existence of the hardpan layer already described. (Figure 75.) In the wetter situations the undergrowth of myrtle and gallberry is much more luxuriant than elsewhere. During the rainy season this soil is inundated and extensive drainage systems must be established before it can be successfully cultivated. Up to the present time little of the type has been utilized, but when reclaimed it should prove an excellent soil for truck crops. It is not adapted to citrus fruits. The unimproved land is held at prices ranging from $15 to $75 an acre.

Portsmouth fine sand, swamp phase.—This phase of Portsmouth fine sand is found only in the northern part of the county and is mainly confined to small depressed areas within the typical soil. These are covered with water all or the greater part of the year, and even when not covered the soil is always in a saturated condition. The soil for the first few inches consists of a black, mucky fine sand, containing somewhat more organic matter than the higher lying typical soil. Below this is a gray to white fine sand extending to a depth of 3 feet and more. Hardpan is not encountered in these depressed areas. In all respects except vegetation, these areas —locally known as cypress ponds or swamps—resemble the water and grass ponds in the southern part of the survey. They are distinguished by a growth of cypress and bay, with some swamp maple and myrtle around the edges. (Fig. 77.)

No attempt has been made to clear and drain any of these areas. If drainage could be successfully accomplished, the soil would no doubt be productive. Their position, however, makes it impracticable to drain the greater part of these areas and their value must lie mainly in the forest growth which they support.

Fellowship Series.

The Fellowship series is characterized by the black to dark-gray or brownish-gray color of the surface soils and by the plastic, sticky character of the subsoil or substratum, which is dominantly drab in color or drab mottled with shades of yellow and brown and sometimes red. These soils occupy rolling, low, flat or nearly flat areas. The rolling portion has good surface drainage, but frequently is poorly drained in the subsoil on account of seepage resulting from the imperviousness of the plastic clay subsoil and substratum. The low, flat areas are always poorly drained and require ditching or tiling for their profitable utilization. The Fellowship soils support a "hammock" growth and forests of pine. The hammock growth consists ordinarily of several varieties of oak, including especially water oak, along with cabbage palmetto, magnolia, bay, sweet gum, and hickory. The material is derived largely, or in part, from limestone and associated sandstone or arenaceous sandstone belonging to the Vicksburg and related formations. A portion of the sandy surface material may represent originally unconsolidated Coastal Plain deposits.

FELLOWSHIP FINE SANDY LOAM.

The soil of the Fellowship fine sandy loam is a gray to dark-gray or black fine sand 6 to 8 inches deep. The subsoil to a depth of 14 inches is an orange to ocherous-yellow fine sand, grading into a fine sandy clay of the same color. Below this is found a yellow to gray fine sandy clay mottled with orange or brown. In the lower portions of the section shell fragments occur, and in places an underlying shell limestone comes within the 3-foot profile. Between the orange sand and the darker colored surface soil there is frequently a layer of almost white fine sand.

The Fellowship fine sandy loam is found in quite extensive areas through the "flatwoods" region north of Sawgrass Lake and extending in a southwesterly direction through Pinellas Park. It seems to occur where the water and grass ponds are most numerous. The areas are flat and represent bodies of the unconsolidated sandy deposits so thin that the underlying country rock lies within or not far below the 3-foot limit of the soil profile. Where the sand covering is deeper the Portsmouth fine sand is developed, and as a result these two types are closely associated. The color and texture of the subsoil of the Fellowship fine sandy loam are due to the proximity of this underlying rock, and in some instances the subsoil may be composed entirely of residual material resulting from the weathering of the rock. The difference between the subsoils of the Parkwood types and the Fellowship fine sandy loam lies in the fact that the material underlying the former has been more thoroughly decomposed and has reached the marl stage and is typically of a lighter color.

Owing to the character of the underlying material, which greatly retards percolation, the Fellowship fine sandy loam is very poorly drained, the surface being covered with water for some time after heavy rains.

The characteristic natural vegetation on the Fellowship fine sandy loam is wire grass, saw palmetto, and longleaf pine.

No portion of this type was seen under cultivation. It would, in all likelihood, prove a strong soil were good drainage established. On account of the nature of the substratum and the extreme flatness of the country, however, drainage would be in all cases costly and in some instances next to impossible, owing to the lack of fall and suitable outlets.

MISCELLANEOUS MATERIAL.

MUCK.

Muck is derived from decayed plant remains which have accumulated in low-lying positions under poor drainage conditions. During the process of decomposition the vegetable material assumes first a loose, fibrous character, in which stage it is known as Peat.

The color of this is usually reddish brown. Further decay results in the formation of a black organic mass in which the original structure and fibrous nature of the plant or vegetative remains are unrecognizable. There is usually present varying though small proportions of mineral matter.

There is considerable variation in Muck as it occurs in Pinellas County. In depth it varies from a few inches to 3 feet or more, and the subsoil may be either a dark-colored fine sand or a black to drab fine sandy clay.

A few of the areas mapped were recognized to be more properly classed as Peat than true Muck, but it was not found practicable to make the separation. These areas no doubt possess a lower agricultural value and are less desirable than the typical soil.

Muck is found scattered throughout the survey in areas of varying size. Several good-sized areas occur in the northeastern part of the county and west and northwest of St. Petersburg. These areas, from the prevalence of the bay tree, are locally called "bays." The large area at Clearwater, known as the "prairie," has only a scattering growth of myrtle and bay, with some clumps of the latter. The Muck surface of this area is very shallow in places, and there are some small knolls of sand which could not be shown on the soil map. There are also in the "prairie" some patches of deeper organic surface soil which catch fire and burn for considerable periods of time. Such patches are more properly Peat.

Smaller bodies of Muck are numerous and many could not be represented on the map on account of their limited extent. These are called "bay heads," on account of the tree growth and the fact that they are usually the source of small streams.

Although 4,608 acres of Muck were mapped in Pinellas County, a very small acreage is under cultivation. A few patches have been drained and used for crops, and on areas around the edge of some of the larger bodies vegetables and strawberries have been successfully produced. Many areas could be profitably cleared and drained. The soil is well adapted to the production of celery, lettuce, onions, cabbage, carrots, Irish potatoes, corn, strawberries, and all garden truck suited to the county. At Sanford, Fla., Muck is considered an excellent soil for the growing of celery, while at Hastings, Fla., it is held in high favor for the production of Irish potatoes.

It is surprising that utilization of Muck has not received more consideration in Pinellas County. It is believed that with drainage and proper methods of management it would prove the most valuable of any of the soils for truck growing.

SWAMP.

In the survey of Pinellas County the term Swamp has been confined to the low-lying soils along stream courses and around the larger inland bodies of water. Other wet, swampy, and poorly drained areas forming cypress ponds, bays, bay heads, and sand ponds have been classified as other types of soil.

The Swamp areas are subject to overflow and are more or less wet the greater part of the year. They support a water-loving vegetation, consisting mainly of cypress, with cabbage palmetto, gum, swamp maple, bay, myrtle, alder, and numerous vines.

The extent of Swamp is small, the largest areas occurring along Brooker Creek and its tributaries and around Lake Butler and Lake Largo.

Swamp soil is rich in organic matter and may consist of mucky black sand, Muck, or Peat. The subsoil varies from a white or black sand to drab or dark-colored fine sandy clay.

The areas of Swamp have no agricultural value, on account of the impracticability of draining them. Location and the character of cypress growing on it determine the prices asked for land of this kind.

COASTAL BEACH.

The Coastal beach includes strips of white and light-gray sand containing varying amounts of shells and shell fragments, occupying a position along the water front. These areas, which owe their formation to the action of waves and tides, have no agricultural value at present.

The keys or islands lying off the mainland are the largest and most important areas. The higher elevations, which are modified by wind action, support a scattering growth of pine, cabbage palmetto, scrub palmetto, and a number of salt grasses. The side of these islands bordering the bay is usually lower than the side bordering the Gulf, and here mangrove bushes grow in profusion. Many of the smaller islands are only slightly elevated above water and are covered with a dense growth of mangrove.

At Green Springs a low, narrow ridge consisting almost entirely of oyster shells has been included in this classification. The ridge, which is over one-half mile in length, supports a dense growth of cedar and scattering live oaks. A few small areas of "made land," composed of material dredged from the Bay of St. Petersburg, were also mapped as Coastal beach.

While the Coastal beach lands are of no practical value for agricultural purposes, the most desirable areas, especially those located along the Gulf shore, command high prices as sites for cottages.

TIDAL MARSH.

Along the coast in many places and fringing the tidal streams and bayous are found low, treeless areas of a marshy character. (See Fig. 80.)

The material in these areas consists of a black or brownish-gray fine sandy or silty loam, containing considerable vegetable matter undergoing the process of decomposition. In many places Tidal marsh resembles Muck, except for the timber growth, and the separation of the two was frequently made solely upon this character.

The largest areas of Tidal marsh occur along the Anclote River, which divides into a number of tortuous channels shortly after entering the county. Other good-sized areas are found bordering the larger bayous and around the numerous inlets.

All areas are subject to frequent tidal overflow and at present are of no agricultural value. They support a water-loving vegetation consisting of marsh grass, reeds, and rushes.

The Tidal marsh when drained and freed from excess salt is productive. Many of the areas could be reclaimed. After drainage the injurious salt will be washed out by the rains. The soil when fitted for cultivation is especially desirable for trucking.

North of Tarpon Springs considerable areas of the Tidal marsh are underlain by limestone, frequently within less than 3 feet of the surface.

SUMMARY.

Pinellas County lies on the west coast of Florida about midway between the northern and southern boundaries. It comprises an area of 166,400 acres, or 260 square miles. It was formed from the western part of Hillsboro County in 1911. The topography is varied, ranging from flat to hilly, the highest points being found in the northern part.

The climate is subtropical. The mean annual rainfall is over 50 inches; the mean annual temperature about 70° F. The winter mean is approximately 60° F., and the summer mean close to 80° F. The climate is one of relatively stable temperature. On account of the pleasant winter weather, thousands of tourists flock to the resorts along the coast.

Transportation facilities are good over a large part of the county. Much shipping is done by water.

Clearwater, the county seat, has a population of about 1,171. St. Petersburg, with a population of 4,127, is in the southern part of the county. Tarpon Springs, in the northern part, with a population of 2,212, is one of the greatest sponge markets in the world. Sutherland, Ozona, and Dunedin are smaller towns in the western part of the county. These are shipping points for citrus fruits grown in their respective communities. Green Springs, the site of Espiritu Santo Springs, is a noted health resort. It is also an important shipping point for the east coast. Largo is one of the chief shipping points for citrus fruits.

Citrus fruits constitute the money crop of the county. Trucking is carried on to a limited extent. No general farming is practiced and practically all grain and hay are imported.

Land values have advanced considerably during the last five years. Unimproved land can be bought for $10 to $75 an acre, and well-established citrus groves for $300 to $1,000 or more an acre.

Eleven types of soils are mapped in the county. These are grouped in six series, with miscellaneous types, as follows: Swamp, Muck, Tidal marsh, and Coastal beach. Types of the fine sand class predominate, there being but two fine sandy loams and one silty clay loam.

The Norfolk fine sand is the most important and valuable soil. It is practically the only type used for citrus orchards and commands the highest price. The hilly phase is a loose, droughty soil. The flat phase contains a high percentage of organic matter and is a strong, productive soil for truck and citrus fruits.

The Portsmouth fine sand is a poorly drained soil, usually underlain by hardpan. When artificially drained it is best adapted to trucking. It is not at all suited to citrus fruit production. The swamp phase supports a heavy and valuable growth of cypress. No attempts have been made to clear and drain these wet areas.

The Leon fine sand occurs typically and in a rolling phase.

The typical soil closely resembles the Portsmouth fine sand in texture and topographic position. It is a flatwoods soil and usually underlain by a brown hardpan layer. It is of low agricultural value. The rolling phase is very droughty and has no agricultural value. The characteristic timber growth is spruce pine, which is not found on any of the other soils of the county.

The Plummer fine sand is an unimportant type occurring only in the northeastern part of the county. It is poorly drained and best suited for pasture land.

The Parkwood soils, consisting of a fine sandy loam and a silty clay loam, are not extensively developed. They occupy low, naturally wet country, but constitute the strongest soils of the county.

The Fellowship fine sandy loam is low lying, and under present conditions not suited for the growing of any crop. With drainage this soil should prove highly productive.

Up to the present time Muck has not been extensively placed under cultivation. If drained, it would be adapted to Irish potatoes, celery, strawberries, and other truck crops.

Coastal beach has no agricultural value. The keys or islands form the largest development of this type.

Tidal marsh represents lowlands along the coast and streams subject to tidal overflow. Many of these areas could be diked and drained and converted into valuable farm lands.

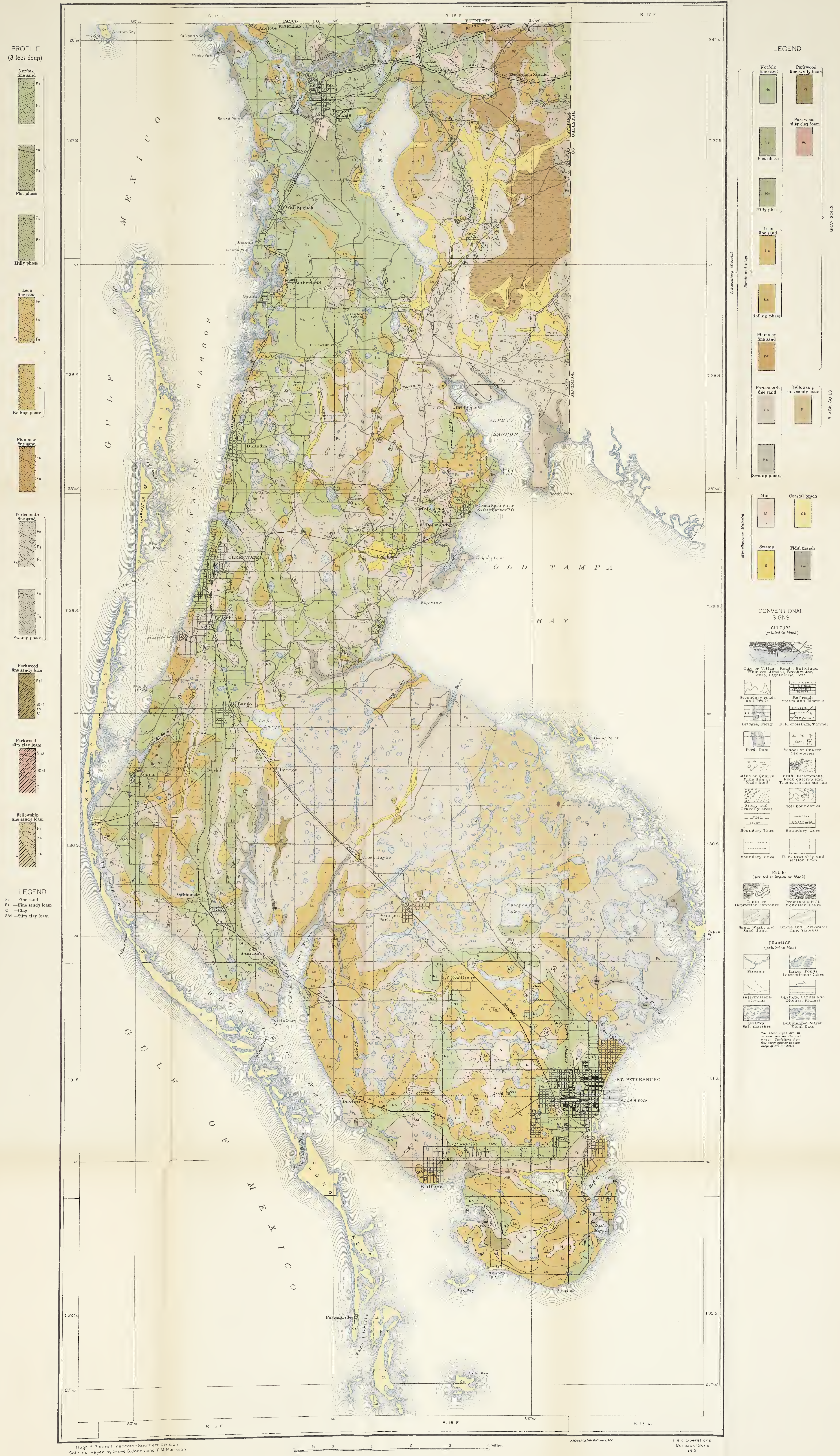
There is a large acreage of undeveloped land in the county, some of which is adapted to the production of citrus fruits and some to the growing of truck. Either of these lines may be profitably extended.

U. S. DEPT. OF AGRICULTURE
BUREAU OF SOILS
MILTON WHITNEY, CHIEF
CURTIS F. MARBUT, IN CHARGE SOIL SURVEY

SOIL MAP

FLORIDA
PINELLAS COUNTY SHEET

FLORIDA STATE GEOLOGICAL SURVEY
E. H. SELLARDS, STATE GEOLOGIST



Hugh H. Bennett, Inspector Southern Division
Soils surveyed by Grove B. Jones and T. M. Morrison

1 ½ 0 1 2 3 4 Miles
Scale 1 inch = 1 mile

A. Hoen & Co. Lith. Baltimore, Md.

Field Operations
Bureau of Soils
1913

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